

TOWARDS A
SUSTAINABLE
FUTURE

ENERGYCONNECTIVITY

IN ASIA AND THE PACIFIC



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Towards A Sustainable Future: **Energy Connectivity in Asia and the Pacific Region**

United Nations publication

Sales no. E.16.II.F.24

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Printed in Bangkok

ISBN: 978-92-1-120733-0

eISBN: 978-92-1-059726-5

ST/ESCAP/ 2757

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TOWARDS A SUSTAINABLE FUTURE

ENERGYCONNECTIVITY

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The energy choices we make today will shape the development of the Asia-Pacific region throughout the 21st century. The global community has recognized that energy is not only central to economic and social progress but also has a profound impact on the environment. This is why energy is critical to the successful implementation of the new universal and transformative 2030 Agenda for Sustainable Development. It is also why Sustainable Development Goal 7 specifically emphasizes the need to ensure access to affordable, reliable, sustainable and modern energy for all, aiming to ensure access, double the share of renewable energy and double the rate of implementation of energy efficiency by 2030.

Driven by the quest for economic growth, and largely reliant on fossil fuels, the Asia-Pacific region already consumes almost half of the world's energy. The strong economic potential of the region, as well as its population pressures and rising middle class, all point to an energy scenario in which Asian energy demand will continue to outstrip that of every other region. The sources of energy we choose to exploit, their efficiency of use, and how we share them across borders, will greatly influence the course of economic development, environmental health and social progress in the region and beyond.

There is growing agreement that Asia's energy challenges can best be addressed through enhanced regional energy connectivity, as well as diversification of energy sources — which will also promote clean energy. Asia-Pacific energy resources, both fossil and renewable, vary greatly in their distribution across countries and subregions. The ability to share and trade these resources, in order to address energy surpluses and deficits, requires physical connectivity infrastructure, such as electricity transmission links and gas pipelines, which in turn require significant financing for construction. Underpinning this goal, however, must be a shared vision, political agreement and the institutional infrastructure necessary for energy exchange between countries, to enable benefits to be equitably shared.

In recent years, Asia-Pacific market integration has advanced at an impressive rate, contributing to the region's strength and resilience in the global economy. In contrast, however, trade in energy has not progressed as rapidly. With the notable exception of a few subregional energy market integration successes, the long-term and capital-intensive nature of the infrastructure required for energy trade, along with the political and institutional complexities involved, have prevented regional energy integration from reaching its full potential. Asia-Pacific regional economic cooperation and integration therefore requires a firm commitment to energy integration, which is also a central element in the development of integrated markets and responses to shared vulnerabilities and risks across the region.

The ratification of the Paris Agreement on climate change, backed by Nationally Determined Contributions (NDCs), has provided new impetus for economies to decarbonize in order to limit global warming to 2 degrees Celsius. Clean energy, as a climate change solution, is now at the forefront of many national policy agendas, and is benefiting from rapid advances in both renewable energy and power transmission technologies. These advances have made decentralized, utility-scale renewable power generation, as well as energy transmission over longer distances, increasingly practical and cost-effective.

The new development and energy paradigm has offered an opportunity to examine, with a fresh perspective, the long-term potential for greater energy connectivity in the Asia-Pacific region, and to outline a road map to realize these possibilities.

Progress towards developing a more interconnected and integrated Asia-Pacific energy system, which increases energy access, lowers costs and facilitates sharing of clean energy resources, will help member States deliver on the ambitious United Nations 2030 Agenda for Sustainable Development, allowing them to better address climate change risks. This will also provide a strong foundation for realizing the full potential of the Asia-Pacific region in the 21st century.

The development of affordable and sustainable energy is essential to meet the needs of both current and future generations, through economic growth and more effective climate resilience, which in turn supports poverty alleviation and improves regional stability. These elements have particular resonance for the Asia-Pacific region as we confront the related issues of growing demand for energy, unequal energy access, urban air pollution and acute concern about the impacts of climate change.

Transforming energy systems in a way that addresses these multiple concerns requires a comprehensive approach, combining national action and regional cooperation. In this context, this report places emphasis on augmenting Asia's energy security through increased regional energy connectivity, on the grounds that this will offer significant potential for increasing access to energy, lowering energy costs and enabling greater use of renewable and low-carbon energy, contributing to the sustainable development of developing and advanced economies alike.

This report also provides a historical perspective on regional energy connectivity and its implementation challenges, as well as outlining an action plan for accelerated regional energy integration to bring shared benefits to ESCAP's member States. The report concludes that energy connectivity can increase the supply and reduce the cost of energy, while lowering its social and environmental costs and addressing the challenges of energy security.

Capturing these benefits for current and future generations in Asia and the Pacific will require enhanced regional energy cooperation between member States, and the creation of regional institutional governance to guide the progress of energy connectivity and integration.



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Acknowledgements

Under the overall direction of Shamshad Akhtar, Under-Secretary-General of the United Nations and Executive Secretary of ESCAP, this report was prepared by Anil Terway and Rita Nangia with support from the following ESCAP staff: Hongpeng Liu, Kohji Iwakami and Michael Williamson; and consultants: Derek Atkinson, Sean Ratka and Kimberly Roseberry.

Towards a Sustainable Future: Energy Connectivity in Asia and the Pacific Region has been prepared, in part, with input from the outcomes of the following events: *Expert Group Meeting on Energy Integration for Sustainable Development in Asia and the Pacific*, held from 14 September 2015 to 16 September 2015 in Irkutsk, Russian Federation; *Regional Workshop on Energy Connectivity and Transboundary Power Trade*, held from 7 November 2015 to 9 November 2015 in Suzhou, China; and *Regional Workshop on Energy Connectivity for Sustainable Development: Vision, Strategy and Initiatives*, held from 14 December 2015 to 16 December 2015 in Bangkok, Thailand.

Participants in these events included: Talyat Aliev (Russian Federation), Elmar Elbling (ADB), Ivan Kutsevlyak (Russian Federation), Mohammad Hossain (Bangladesh), Qing Long, (China Southern Power Grid Co., Ltd.) Ram Prasad Dhital (Nepal), Soma Dutta (ENERGIA), Thiyagarajan Velumail (UNDP), Vladimir Krasnogorsky (Russian Federation), Xungpeng Shi (National University of Singapore), Yayoi Yagoto (IEA), Yingxin Xu (Electric Power Planning & Engineering Institute), Zhao He (Electric Power Planning & Engineering Institute), Boris Saneev (Melentiev Energy Systems Institute of the Siberian Branch of the Russian Academy of Sciences), Alexander Sokolov (Melentiev Energy Systems Institute of the Siberian Branch of the Russian Academy of Sciences), Dmitry Sokolov (Melentiev Energy Systems Institute of the Siberian Branch of the Russian Academy of Sciences), Han Huang (China), Lu Hong (China), Feng Gao (China), Caihao Liang (China), Gesong Chen (China), Zheng Fan (China), Qingdong Feng (China), Choy So Yuk (China), Hu Runqing (China), Yanzhong Li (China), Alex Shaw (China), Litthanoulok Laspho (Lao People's Democratic Republic), Sabar MD Hashim (Malaysia), Yeren-Ulzii Batmunkh (Mongolia), Sagar Raj Goutam (Nepal), Sujet Supranee (Thailand), Nawaporn Makthongmanee (Thailand), Nicholas Dunlop (Climate Parliament), Sanjay Kumar (Climate Parliament), Waseqa Ayesha Khan (Climate Parliament), Kalikesh Singh Deo (Climate Parliament), Abdallah Khawaldeh (Climate Parliament), Qian Liu (Golden Concord Power Group), Shubin Niu (Golden Concord Power Group), Zhongyi Du (Golden Concord Power Group), Zhang Wei (Golden Concord Power Group), Shihong Wang (Golden Concord Power Group), Xiyuan Zou (Golden Concord Power Group), Kevin Jianjun TU (International Energy Agency), Matthew Wittenstein (International Energy Agency), Yong Chen (International Renewable Energy Agency), Junfeng Li, Geng Dan, Ying Wang, and Chuan Tian (National Center for Climate Change Strategy and International Cooperation, China), Irene Giner-Reichl (REN21 Secretariat), Jin Qi (Silk Road Fund), Yang Jiehan (Silk Road Fund), Xiao-Ping Zhang (University of Birmingham, UK), MD Shazibul Hoque (Bangladesh), Ugyen (Bhutan), Tashi Choeden (Bhutan), Kunleang Heng (Cambodia), Vitou Sean (Cambodia), Rao Jianye (China), Du Wennan (China), Ali Gholampour (Iran, Islamic Republic of), Hiroshi Kozaki (Japan), Daisuke Yoshino (Japan), Satoshi Yoshida (Japan), Tatiana Vedeneva (Kyrgyzstan), Khamso Kouphokham (Lao People's Democratic Republic), Atarjargal Tserendoo (Mongolia), Keshab Dhoj Adhikari (Nepal), Ilya Andreev (Russian Federation), Ksenia Sergeevna Kushkina (Skolkovo), Natalia Karmazinskaya (Russian Federation), Konstantin Kozlov (Russian Federation), Merrille Godfrey Abeywickrama Goonetilleke (Sri Lanka), Ajith Premalal Rajapakse Pathirage Don (Sri Lanka), Yongyooth Horthong (Thailand), Bongkoch Chahamanont (Thailand), Harid Khaoluang (Thailand), Nar Bahadur Khatiwora (UNDP), Rustem Sauranbaev (Electric Power Council of the Commonwealth of Independent States), Iurii Lyskov (Electric Power Council of the Commonwealth of Independent States).

Abbreviations and Explanatory Notes

ACM	(the Netherlands) Authority for Consumers and Markets
ADB	Asian Development Bank
AMEM	ASEAN Ministers on Energy Meeting
APAEC	ASEAN Plan of Action for Energy Cooperation
APEA	Asia-Pacific Energy Agency
APEC	Asia-Pacific Economic Cooperation
APEF	Asian and Pacific Energy Forum
APG	ASEAN Power Grid
ASEAN	Association of Southeast Asian Nations
BCF	Billion cubic feet
BCM	Billion cubic metres
BIMP-EAGA	Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area
BNEF	Bloomberg New Energy Finance
BoS	Balance of systems
BRICS	Brazil, Russian Federation, India, China and South Africa
CAREC	Central Asia Regional Economic Cooperation
CASA-1000	Central Asia South Asia Electricity Transmission and Trade Project
CCS	Carbon capture and storage
CEER	Council of European Energy Regulators
CFPP	Coal-fired power plant
CHP	Combined heating and power
CPS	Current Policies Scenario
CRIE	Comisión Regional del Interconexión Eléctrica
CROP	Council of Regional Organizations in the Pacific
CSP	Concentrated solar power
EAEU	Eurasian Economic Union
ECLA	Economic Commission for Latin America
ECO	Economic Cooperation Organization
EE	Energy efficiency
EEC	Eurasian Economic Commission
EIA	Energy Information Administration, US Department of Energy
EIRR	Economic internal rate of return
EOR	Ente Operador Regional
ENTSOE	European Network of Transmission System Operators for Electricity
EPR	Empresa Propietaria de la Red
ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European Union
FBC	Fluidized bed combustion
FERC	Federal Electricity Regulatory Commission
FIRR	Financial internal rate of return
FOB	Free-on-Board
GDP	Gross domestic product
GHG	Greenhouse gas
GMS	Greater Mekong Subregion
GTS	Gasunie Transport Services
GW	Gigawatt

GWh	Gigawatt hours
HCB	Hidroeléctrica de Cahora Bassa
HDI	Human development index
HELE	High-efficiency, low-emissions
ICE	Intercontinental Exchange
IEA	International Energy Agency
IGC	Inter-Governmental Council
IGCC	Integrated gasification combined cycle
IGM	Intergovernmental memorandum of understanding
IMT-GT	Indonesia-Malaysia-Thailand Growth Triangle
INDCs	Intended nationally determined contributions
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
kgoe	Kilogram of Oil Equivalent
kW	Kilowatt
kWh	Kilowatt hours
LCOE	Levelized cost of electricity
LHV	Lower heating value
LNG	Liquefied natural gas
MBD	Million barrels per day
MCM	Million cubic metres
MDGs	Millennium Development Goals
MER	Mercado Eléctrico Regional
MESSAGE	Model of Energy Supply Systems Alternatives and their General Environmental Impacts
MMBtu	Million British thermal units
MoU	Memorandum of understanding
MPa	Megapascal
MT	Metric tons
Mtoe	Million tons of oil equivalent
MTPA	Million tons per annum
MW	Megawatt
MWh	Megawatt hours
NAFTA	North American Free Trade Agreement
NAPCI	Northeast Asia Peace and Cooperation Initiative
NDCs	Nationally determined contributions
NOx	Nitrogen oxides
NPS	New Policies Scenario
NREL	National Renewable Energy Laboratory
NTS	National Transmission System
NYMEX	New York Mercantile Exchange
O&M	Operations and maintenance
OECD	Organisation for Economic Co-operation and Development
PC	Pulverized combustion
PIF	Pacific Islands Forum
PJM	Pennsylvania-New Jersey-Maryland Interconnection
PM	Particulate matter

PPP	Public-private partnership
PRC	People's Republic of China
RE	Renewable energy
REN	Rede Energética Nacional
RPCC	Regional Power Coordination Centre
RPTCC	Regional Power Trade Coordination Committee
SAARC	South Asian Association for Regional Cooperation
SAPP	Southern African Power Pool
SASEC	South Asia Subregional Economic Cooperation
SCO	Shanghai Cooperation Organization
SDGs	Sustainable Development Goals
SE4All	Sustainable Energy for All
SIEPAC	Sistema de Interconexión Eléctrica de los Países de América Central
SOE	State-owned Enterprise
Solar PV	Solar photovoltaic
SOx	Sulfur oxides
SPPV	Special purpose public vehicle
TA	Technical assistance
TAGP	Trans-ASEAN Gas Pipeline
TAPI	Turkmenistan-Afghanistan-Pakistan-India
TCF	Trillion cubic feet
tco₂e	Tons of carbon dioxide equivalent
toe	Tons of oil equivalent
TSO	Transmission system operator
TTF	Title Transfer Facility
TWh	Terawatt hour
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
US	United States of America
USD	United States dollars
VRE	Variable renewable energy
WEO	World Energy Outlook
WGP	Working group for coordinating performance standards and grid codes
WGRI	Working group for regulatory issues

Reference to “tons” indicates metric tons.

References to dollars (\$) are to United States dollars, unless otherwise stated.

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The Context

The global leadership at the United Nations adopted the 2030 **Agenda for Sustainable Development** in September 2015. Goal 7, on affordable and clean energy, aims to ensure access to affordable, reliable, sustainable and modern energy for all by 2030. The task at hand is extremely challenging; despite enormous economic success, the Asia-Pacific Region (the Region) is home to the majority of the world's energy-poor, lacking access to electricity and still using traditional fuels for cooking and heating, which raises significant environmental concerns, health problems and gender inequality issues. Access to energy is essential for facilitating modernization of individuals, communities, nations, and the Region. Some of the linkages between access to modern energy and economic growth and poverty reduction are direct, as energy is a key input into industrial development, quality of life, transportation and communication networks. Others are indirect — e.g. effective health care service delivery requires access to modern energy sources.

Three future trends are likely to dominate the sustainable development agenda for the Region. First, the next few decades will see a tremendous rise in the urban population globally, but particularly so in the Region, and new cities and new buildings will have to be built to cope with rapid urbanization. Second, the world will witness a major rise in the middle class: from 1.8 billion people in 2009 to 4.9 billion by 2030. Asia will account for 66 per cent of the global middle class population and 59 per cent of global middle-class consumption, compared to 28 per cent and 23 per cent, respectively, today. The emergence of a large middle class will have significant impact on energy demand as well as on goods and services that have embedded energy. Finally, many countries will create new infrastructure including energy networks to serve the large and growing demand for energy services in the next few decades. The Region is expected to account for over 40 per cent of the \$68 trillion cumulative energy investments until 2040. In today's connected world, no country alone can meet the challenges. This visionary document aims to explore regional energy connectivity to meet broader energy goals within the framework of the Sustainable Development Agenda.

The Asia-Pacific Region is among the most diverse regions of the world in terms of geography, size of the economy, population and community, economic conditions, poverty and social situations, energy use patterns and resource endowments, environmental conditions, and overall quality of human well-being, as well as different forms of governments and political systems. High and sustained economic growth over the last several decades has led to rapid rise in energy consumption and the Region now accounts for almost 50 per cent of global energy consumption.¹ In spite of large investments in domestic production capacity in the last two decades, the Region has transitioned from being a net exporter of energy until 1990 to being a net importer today. Compared to 1980, the Region's share has nearly doubled, from 23 per cent to over 42 per cent of global energy imports in 2012. More importantly, the Region is particularly vulnerable in terms of over-dependency for oil imports on a single geopolitical region, with the associated risks of supply disruption in shipping bottlenecks.²

- I. Coal is abundantly available in many locations and of various grades, whereas oil reserves remain concentrated in a few countries of the Region. Of the estimated 892 billion tons of international coal reserves, approximately 55 per cent is within the Region. Of the current total world oil reserves (approximately 1,700 billion barrels), the Region only accounts for approximately 20 per cent. Natural gas is more widely distributed than oil on a global level, but the bulk of proven reserves are still concentrated in the Middle East. The Region has abundant renewable resources, including hydropower, solar, and wind.

The Challenges

Though the Region has adequate energy resources to meet its large and growing demand, most resources are highly concentrated in a few countries. The top five countries account for over 85 per cent of total regional resources and are not the countries where the demand is expected to grow. In such conditions, trade is always beneficial and can be an important driver for regional energy connectivity. Unlike the global production networks that created a positive force for reinforcing the bottom-up market integration process, many more efforts are needed to connect the energy markets of Asia and the Pacific Region. Trade and investments in regional energy networks remain low, aside from some cross-border investments, even though there are beneficial opportunities waiting to be tapped.

A number of factors are responsible for this disconnect. Energy networks are capital-intensive and, given their large sunk costs, they present major challenges in financing and maintenance, especially when these are subject to different legal and regulatory regimes. When energy markets are dominated by state ownership, investments from private sources are difficult to attract because of the lack of creditworthiness of state enterprises and opaque governance structures. In the current situation, even if subregional support is present, cross-border projects have large transaction costs and it takes an extended period for any project idea to move from the drawing board to secure multiple approvals and reach actual implementation.

There are large positive and negative externalities inherent in energy connectivity. Invariably, there are problems in measurement of the costs and benefits, and in designing policy regimes that can fully address these externalities. Balancing the gains with overall costs among different groups of stakeholders needs a robust institutional mechanism. The energy integration process is not limited to just the creation of physical links across borders; it requires a series of policies and regulations for facilitating different types of flows inherent in the process. The subregional energy integration programmes generally show a lack of consensus in defining a comprehensive model of integration. Finally, energy security issues are of prime importance to the political leadership and it was believed, given the emphasis on domestic production in most sectors of the economy, that national energy security would be compromised through regional energy trade.

The Drivers

For the first time, technical advances and improved economics of energy technologies have helped create favourable market conditions in the Region. Solar and wind options are becoming cost-competitive in many locations. It is feasible to integrate large-scale distributed networks and renewable energy options with traditional power systems, which will stimulate private investment flows if the regulatory barriers for energy trade are removed. What is needed is to replicate the success of global supply chains in the energy sector so that markets jump-start the process of connectivity and integration, given that many important drivers of energy connectivity are already present in the Region.

The first important driver is the political will. A number of countries and all subregions consider regional connectivity to be an essential instrument for dealing with current energy and environmental challenges. Both political leaders and policymakers have committed to connecting energy networks; these include the ASEAN, APEC, GMS, CAREC, EAEU, SAARC organizations, evident from regional mandates summarized in Chapter IV. At the 2013 Asia-Pacific Energy Forum (APEF), Economic and Social Commission of Asia and the Pacific (ESCAP) member States were requested to promote

an Asia Pacific Energy Security Cooperation Framework. This initiative, which includes a transAsian energy system, would help to ensure both the near- and long-term energy security of the Region. It would connect producers and consumers of energy resources and facilitate new markets for clean and efficient energy technologies. Its goal is to shift the Region to a low carbon path while ensuring universal access to energy within a predictable time frame.

It needs to be recognized that what constitutes energy security is as diverse as the Region itself; for an individual country or even a part of a country, energy security needs to encompass all risks including natural, technological, economic, and ecological uncertainties, in addition to the traditional concerns of disruptions to energy supplies, physical or cyber threats to energy networks, price manipulations, high import dependence or macroeconomic affordability of the universal access goal. Regional energy connectivity enhances energy security through diverse channels.

The disparity between energy demand and resource endowment means that there is significant potential to reduce overall energy costs in the Region and introduce an increased diversity of sources, including renewable energy. Deepening natural gas use will help meet growing demand by substituting coal with a less carbon-intensive energy source. A regional approach will also help to develop non-conventional gas resources such as coal-bed methane and shale gas. The Region, with its heavy dependence on fossil fuels, will benefit significantly by expanding the use of renewables; large electricity grids spread over vast geographical areas are well suited to accommodating large shares of intermittent wind and solar power. Finally, regional cooperation reduces overall costs and thereby contributes to enhanced energy security, especially in countries where affordability and access are major sources of energy insecurity.

Regional energy connectivity results in major benefits due to cost savings for additional generation capacity through complementary demand profiling, lowered reserve margins, improved load factor, improved load mix, and coordinated maintenance schedules. Overall, resource pooling affords complementarities and comparative advantages for the fuel sources used in power generation and lowers overall costs. Most energy infrastructure is path-dependent and difficult to change because of technology lock-in effects. Since most of the Region's energy infrastructure is yet to be built, it can leapfrog to cleaner technologies using regional integration approach. Regional energy connectivity will increase energy supplies that can be used to connect remote regions to modern energy, and thus also contribute to the goal of sustainable energy for all. Given the strong production networks and supply chains in Asia, expansion of distributed and renewable energy systems will also create new opportunities for trade and investment, leading to job creation and economic growth.

Lessons from the Existing Connectivity

Regional cooperation in energy has been evolving mainly through five subregional clusters — South-East Asia, Central Asia, South Asia, North-East Asia, and the Pacific. The small island nations in the Pacific have a very different perspective on energy connectivity; while physical infrastructure is unviable, software for managing energy security risks can be better organized through close cooperation.

At present, three institutional arrangements are used for supporting energy cooperation in the Region. The first one, which encompasses all countries, is led by ESCAP, which is the principal global body for coordination, policy review, policy dialogue, and recommendations on economic, social and environmental issues. The second institutional arrangement is subregional programmes led by the countries. Regional

cooperation through these programmes remains contingent on voluntary, unanimous and continuous decisions of members. The third arrangement includes the facilitating institutions such as the Asian Development Bank, the World Bank and bilateral aid organizations that support regional cooperation in a variety of ways. As explained in Chapter V and Appendix 3, there are ten subregional programmes promoting energy connectivity in the Region.

A great many resources have been spent on bringing the subregions together; however, overall results remain below the potential. One of the main reasons for the slow progress is the decision-making process for cross-border projects. Country participation in the subregional programmes is voluntary and the decision-making process is through dialogue and consensus. This has favoured the implementation of bilateral infrastructure projects that required an agreement between only two governments. Even for these projects, consensus building has taken years in cases of major infrastructure projects. The level of delay and uncertainty has been frustrating for private sector project developers and institutional lenders.

The regional diversity in terms of large differences in level of energy consumption, industry structures, human and institutional capacity, and resource base has made it difficult to start work on massive interconnection projects or supergrids that can result in large economic and environmental benefits. Officials know that harmonization of rules and standards will be necessary but there is no institutional mechanism to coordinate the actions taken by member countries. The preparation of bankable proposals for regional interconnection and export-linked electricity generation projects is given a low priority, lacks resources and remains uncoordinated. There are several conceptual proposals for regional energy connectivity but these lack thorough techno-economic feasibility analyses for establishing their viability. There is no single institutional mechanism or framework that treats the linked components as a single project and analyses it in its totality.

Globally, the electricity business changed in the United States and Europe at about the same time. The United States moved to unbundle state utilities to create competitive markets whereas a single European electricity market was launched in 1996. The business model is defined by non-discriminatory open access to networks, competition in wholesale and retail supply, and addition of new assets on the basis of market-determined prices. The European Union (EU) allowed flexibility to individual countries with regard to industry structure but required them to disclose the rules and not to discriminate. The experience with competitive wholesale electricity markets across borders has generally been positive in mature economies where electricity consumption has flattened out or is declining. The industry is better equipped to face new challenges, it remained financially sound while fuel prices peaked in 2008 and it is also shifting to power generation using renewable energy resources to lower the carbon footprint. The same approach is being used in the wholesale gas markets that are supplied using extensive pipeline networks.

Several interesting and useful lessons can be drawn from the analysis of international experience with integrated energy markets. It is possible to accommodate different structures of the energy sector in member countries while designing instruments for regional energy trade. Bilateral energy trade can be developed based on contracts but wholesale competitive markets are better for taking full advantage of the diversity among member countries. Large investments are needed to capture the benefits of energy trade, which requires private sector investment. It is possible to have markets for regions with relatively low energy consumption and also for very large energy-consuming areas. Although wholesale markets send price signals, this is not a sufficient condition for attracting private sector investments; project developers and lenders make their own projections for which all energy-related data has to be publicly available. Markets require adjustments from time to time to maintain a balance between the interest of investors and energy consumers. Robust institutions have to be created for promoting and managing regional energy trade.

Towards Asian Energy Connectivity

Energy markets do not connect by themselves; in the next few decades, actions will be needed to build physical energy networks, institutional connectivity and, most importantly, trust between nations to meet the Region's two most important challenges — overcoming energy poverty and mitigating climate change. Governments, policymakers, and experts must work together in partnership with the private sector to provide sustainable energy for all by 2050 by connecting Asian energy networks and building institutions of integration. ESCAP is in a unique position to lead such a transformative partnership for ensuring that regional energy connectivity creates incentive structures and institutions to deliver cost-effective energy for the entire Region. It is time to build energy connectivity for an interdependent Asia and the Pacific — prosperous and connected — thus ending Asian economic dependence on a single source or a single fuel.

By 2050, the vision is to have a connected and fully energized Asia- Pacific region in which:

1. energy interdependence fosters harmonious relations among members and thereby yields a peace dividend that improves quality of life and overall well-being, supports wealth creation and protects the environment for future generations;
2. expanded supply and robust networks enable universal energy access and delivery of crucial social services including education, health, communication and leisure;
3. reliable energy supply supports the member economies in creating employment opportunities and robust economic growth;
4. large regional renewable energy resources — hydropower, wind, solar, geothermal and tidal power — are unlocked;
5. technologies that reduce ecological footprints are mainstreamed — e.g. efficient fossil fuel production and conversion;
6. innovations in transportation and other energy applications help de-carbonize economies;
7. additional resources sourced from the private sector for implementing cross-border infrastructure under public-private partnerships (PPP) help create robust and competitive energy markets;
8. improved regional energy governance strengthens transparency and streamlines approvals of regional projects including transnational natural gas pipelines, power grids and secured energy transportation routes;
9. harmonized energy policies, regulations and standards lower overall risks;
10. a conducive environment is created whereby innovations and local adaptations allow countries to leapfrog to cleaner and sustainable energy sources; and
11. thought leadership and knowledge-pooling underpin sustainable development of the energy sector and thus the entire region.

Action Plan

The Ministerial Declaration of APEF 2013 has recognized that enhanced energy trade is a powerful catalyst for strengthening intraregional cooperation, energy security and sustainable use of energy; furthermore, action will be needed to cover both physical networks and institutional aspects of regional economic integration. Five action points are suggested to achieve the long-term goal of regional energy integration of the Region.

Action 1: Remove barriers to energy trade. Though governments realize many benefits of greater regional energy connectivity, a number of countries have restrictions on exports and imports of energy goods and services. The first step in regional energy connectivity, therefore, has to address the issue of explicit or implicit trade restriction.

Action 2: Improve the investment climate. The industry structures for energy in the Region remain quite diverse. Regional energy connectivity can bring new investments, efficiency improvements and new technologies. However, realizing these dividends requires governments to carry out sector liberalization, modernize monopolistic utilities and rationalize the government's role in creating competitive market structures. Although the Region has adequate savings at macro level, collective actions to promote private investment in secure energy connectivity have yet to be taken.

Action 3: Create an Asia-Pacific Energy Charter. There is more than enough political support for regional energy connectivity. At various fora, technical experts have quantified the benefits of greater energy connectivity. At subregional levels, too, there have been many declarations of intentions to promote energy connectivity. It is proposed that these declarations and intentions be formalized in the shape of an Asia-Pacific Energy Charter. This will help to convey the long-term commitment of member governments and provide confidence for the private sector and institutional investors.

Action 4: Establish institutions of regional energy integration. Integrated markets require integrated institutions. A number of institutional mechanisms to promote greater cooperation across Asia and the Pacific region have been set up, but these are mostly limited by their mandates for the subregional programmes and add little to the vision of energy integration for the entire Region. Institutional design will be fundamental to developing and sustaining competitive energy markets for the Region in the long run.

Action 5: Engage in knowledge-sharing, and capacity-building. The global energy sector is undergoing multiple transitions³ and human and institutional capacities need to be built to benefit successfully from these changes. Country-level information systems need to be enhanced to share knowledge and learning. There is also a large potential for developing common standards and documentation for promoting private sector investments.

Institutions of Regional Integration

In addition to creating the Asia-Pacific Energy Charter, it is proposed to establish two institutions, the Asia-Pacific Energy Centre and the Asia-Pacific Energy Agency, with mandates to implement the regional energy connectivity.

The objective of the Asia-Pacific Energy Charter will be to assure the private sector, institutional investors and other stakeholders about the Region's collective approach for improving energy security and sustainable use of energy. Many important elements of such a charter were already agreed at the APEF Meeting of 2013. One key to the success of regional integration would be to define the basis for fairness — i.e. what will be considered to be fair and equitable sharing of costs and benefits of energy trade.

The proposed **Asia-Pacific Energy Centre** will fill the knowledge gaps and build the regional expertise in energy policies and planning for energy connectivity for the Region. The role of the Asia-Pacific Energy Centre will be to assimilate and disseminate all energy-related data and reports from member countries and to build an understanding of energy production and use, including analysis of clean cooking fuel. A key to private sector investments will be timely information about energy production and use. Investors will be able to build their own scenarios so the need for ready availability of robust data cannot be understated. The Centre will hold regular consultations with the United States and Europe, the other two large energy-consuming regions and this will increase energy security for all.

While several cross-border projects have been implemented in the Region, these followed an opportunistic approach. Useful lessons have emerged but they have not yet developed into a systemic approach that significantly lowers the time and transaction costs of dealing with multiple agencies and holding protracted negotiations. A professionally managed regional entity, the **Asia-Pacific Energy Agency**, a special purpose public vehicle, is proposed for focusing on implementation of cross-border energy connectivity infrastructure projects. It will ensure that all stakeholders (mainly governments, the private sector and civil society) work towards a shared goal and create synergy. The scope of the proposed special purpose public agency will include preparing pre-feasibility studies for transnational infrastructure, drafting PPP contracts that reflect the requirements of bankable projects, developing transparent competitive process for projects, assisting member governments in negotiating with private sponsors, and ensuring that projects will lead to open-access competitive markets. If necessary, the Asia-Pacific Energy Agency will mediate between parties when there is a dispute and help to evolve regional energy markets. The creation of the energy agency will not take away the authority of national governments over the national energy resources, as governments will continue to approve all investment in their territories. However, the member governments will need to share some of the responsibility for managing the project development and implementation processes in a time-bound manner and guiding operation of physical infrastructure during the initial years.

Justification for New Institutions of Regional Integration

The proposed Asia-Pacific Energy Centre and the Asia-Pacific Energy Agency will comprehensively pursue the vision of energy connectivity in the Region. Two organizations with clear mandates, autonomous structures, and full-time professionals will be better equipped to address the challenges in implementing transnational energy projects and facilitate fair and equitable distribution of costs and benefits. Furthermore, the two organizations require very different skill sets and so their functions cannot be combined into one. The Asia-Pacific Energy Centre will require knowledgeable energy economists and statisticians who will generate policy options based on robust analytical work, whereas the Asia-Pacific Energy Agency will require project management, procurement, financial, legal and negotiation experts, who will develop a pipeline of bankable projects.

Some would say that the existing subregional cooperation organizations already have secretariats and some have functioning energy centres that could perform this role. The reality is that all these groups have fragmented mandates covering their own priorities and geographical areas. At present there are no regional institutions of integration to promote energy connectivity for 53 ESCAP member States. It is a challenging task to transform existing subregional institutions and extend their mandates to cover the entire region. It would be a considerable challenge to convert them to autonomous organizations and to work on areas beyond the subregion. Politics, institutional and human capacity constraints and financial resources also remain big hurdles in extending their mandates to cover the proposed actions. The existing staff may accept the new mandate, but their structure is based on country representation and it will be difficult to overcome boundaries and work towards a shared objective of energy connectivity across the Region.

There is no existing institution like the proposed Asia-Pacific Energy Agency. It is important to set up such an institution because the current transaction costs and time lag for developing even cross-border projects is unacceptable. The examples provided in the report show that projects like the gas pipeline from Turkmenistan to Afghanistan, Pakistan and India have already taken 20 years without the project reaching financial closure. The Region cannot afford to wait for an extended period of time for these projects to conclude, nor the financial and environmental costs of not integrating markets.

ESCAP, responding to the request by the APEF, has already initiated steps to strengthen its own energy capacity. The information and expertise-sharing function is underway. After the APEF members give consent and endorse the vision of energy connectivity in the Region, ESCAP can lead the establishment of the two organizations. Partnership with existing financial institutions, bilateral agencies and member governments will help ESCAP raise resources for carrying out the initial activities linked to signing of the Asia-Pacific Energy Charter and establishment of the Asia-Pacific Energy Centre and Asia-Pacific Energy Agency.

Conclusion

The Region's geography can have an important positive impact, driving energy integration and connectivity. The long history of the Silk Road has created a large reservoir of cross-border social capital, comprising linked histories and cultures. Some of the remote regions have better linkages with communities in neighbouring countries than with the central government in their own country. Social and cultural similarities beyond border regions help create linkages and networks because it is often seen that when communities bond in recognized and comfortable groupings, based on trust, reciprocity and agreed norms of behaviour, there are fewer chances of failure. A large number of cross-border energy trade linkages can be scaled up, provided the negative impacts are mitigated and positive impacts are supported through structure of incentives.

In conclusion, one cannot solve all energy challenges through regional integration, but smart region-wide energy connectivity would go a long way towards improving energy supply and addressing the environmental impacts of energy. It is possible for the Region to expand supplies, reduce the overall cost of energy produced and consumed, lower environmental and social costs and reduce energy insecurities by connecting the energy networks. If there are so many benefits arising from energy connectivity, why is it that energy trade remains far below potential and a very large number of countries continue to face energy shortages while other countries are unable to use their resources? The vision document has been prepared to help steer a new course towards energy connectivity across the entire Asia-Pacific region.



Chapter 1

Introduction and Overview

Background

The global leadership at the United Nations adopted the 2030 Agenda for Sustainable Development in September 2015. Universal energy access is an important goal to transform the world of development and the Agenda is intended to stimulate action such that by 2030, affordable, reliable, modern energy service for all becomes a reality. The task at hand is extremely challenging: despite enormous economic success, the Asian-Pacific Region (“the Region”) is home to the majority of the world’s energy-poor population, with 455 million people lacking access to electricity. Nearly 1.8 billion people rely on traditional fuels for cooking and heating, which raises significant environmental concerns, health problems and gender inequality issues (ESCAP, 2015).



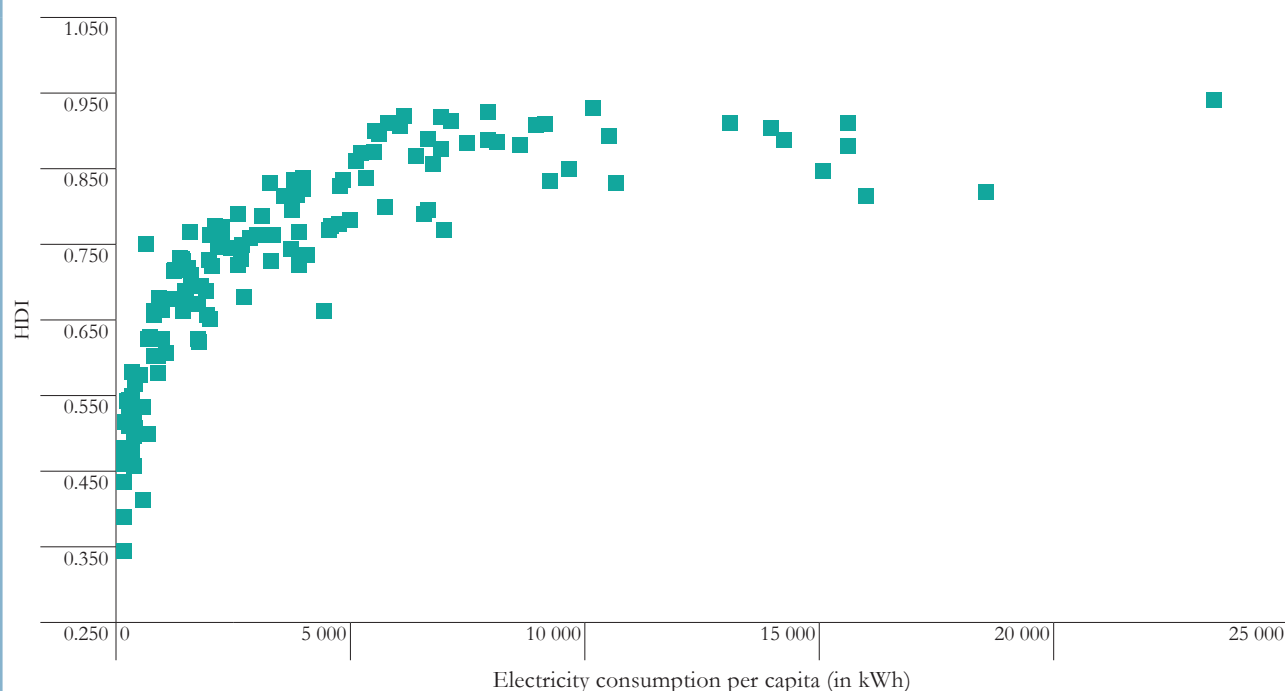
Sustainable energy for all is the answer to some of the key challenges of our time — poverty, inequality, economic growth and environmental risks.

Ban Ki-Moon⁴

Access to energy is essential for modernizing individuals, communities, nations and regions. Some of the linkages between access to modern energy and economic growth and poverty reduction are direct. Energy is a key input for industrial development, transportation and communication networks. Other linkages are indirect — effective health-care service delivery likewise requires access to modern energy sources. Thus, from job creation to economic development, from security concerns to the status of women, energy lies at the heart of the development process. Energy alone is not sufficient for ensuring economic growth, but it is certainly necessary as it is impossible to operate a factory, run a shop, grow crops or deliver goods to consumers without using some form of energy.⁴

Energy plays a crucial role in improving overall quality of life. In particular, the shift from primary energy to electricity is a key feature of modern society and the impact of electrification on quality and standard of living is significant, with benefits for general health, opportunities for more productive activities that can generate additional sources of income and new possibilities for education and media. In fact, several studies have established a link between the human development index (HDI) for a country or province and access to modern energy sources. Figure 1.1 illustrates the fact that most countries with a high HDI also have relatively high levels of electricity consumption. The corollary also seems to be that a low level of electricity consumption is associated with very low HDI.

Figure 1.1 HDI and Electricity Consumption - World



Source: UNDP (2014) *Human Development Report for HDI* and IEA (2015) *Key World Statistics for electricity consumption data*.

Three future trends are likely to have important impacts on the sustainable development agenda in the Region, reshaping the role of energy, economic growth and sustainable development. First, a large number of countries will have to create new infrastructure, including energy networks to serve the large and growing demand for energy services in the next few decades. Second, the next few decades will see tremendous increase in the urban population and new cities and buildings will have to be built to cope with rapid urbanization. Third, the world will witness a major rise in the global middle class: from 1.8 billion in 2009 to 4.9 billion by 2030. Asia will represent 66 per cent of the middle class population and 59 per cent of global middle-class consumption. The emergence of a large middle class will have a significant impact on energy demand and on consumption of goods and services that have embedded energy. These trends are challenging but they also present opportunities to integrate environmental responsibility into the new infrastructure investments that have yet to be made.

This report is about exploring regional connectivity to meet broader energy goals within the framework of sustainable development. The report covers the challenges in meeting growing energy demand while addressing the Sustainable Development Agenda, which covers efficiency of energy used, the role of renewables, energy access and innovation and knowledge-sharing. There is a large volume of knowledge available containing different narratives of how regional connectivity to meet broader energy goals within the framework of sustainable development was achieved in countries that are developed today. Europe's integration, for example, was rooted in the infrastructure networks that were created long before the formal integration process started in the 1950s. This report highlights opportunities and actions that are needed to meet the goals of the energy sector. In today's connected world, no country alone can meet the challenges and so the report focuses on the role stakeholders beyond borders will play in meeting this challenge.

The remaining part of this chapter will present energy conditions in the Asia-Pacific Region. The following two sections will discuss the role of connectivity in the development process and various global and Asian mandates for energy connectivity. Chapter II will examine drivers of energy connectivity in the context of the regional conditions. Chapters III and IV will look at the existing linkages and lessons from the case studies, both within the region and from outside the region. Chapter V will aim to articulate a vision for regional energy connectivity and Chapter VI will present institutional arrangements to deliver the proposed energy connectivity mandates.

Energy and Sustainable Development in the Region

The Asia-Pacific Region is among the most diverse regions of the world in terms of geography, size of the economy, population and community, economic conditions, poverty and social circumstances, energy use and resources, environmental impacts, and overall quality of human well-being. While the Region has the world's seven most populous nations, it also has some of the smallest nations, with populations of only thousands. There are also various forms of government and political systems. The Region has some of the biggest energy producers and consumers. The Region is the world's largest trading partner (ESCAP, 2012). The Region has four of the ten largest economies of the world, but 15 per cent of the total population still lives in extreme poverty. The Region has experienced average growth of nearly 7 per cent per year in nominal terms and 3.9 per cent per year in real terms, much higher than the global average in the last few decades (Figure 1.2). As a result, the Region was able to increase its overall share of global gross domestic product (GDP) (in 2005 USD) from 21 per cent in 1990 to 32 per cent in 2013. In terms of purchasing power parity adjusted GDP, the Region accounts for 47 per cent of global GDP. A number of selected indicators for the region are presented in Table 1.1. It should be recognized that there are regional differences among the five subregions; countries differ a great deal in their overall economic and demographic conditions as well as endowments, usage, availability or cost of energy delivered. For example, Australia, like other developed countries in the region has 80 times electricity consumption per capita of countries like Nepal. Even within countries there are large variations, between urban and rural, or inland versus coastal areas.

Higher economic growth has also meant rapid rise in energy consumption and imports. The Region now accounts for almost 50 per cent of global energy consumption.⁵ To meet rising energy demands, the Region has embarked on large investments in energy production capacity over the last two decades. The electricity sector has grown at double the global rate and as a result, over 40 per cent of the global electricity generation is now taking place in the Region (Figure 1.3). Overall electricity generation increased from 2.6 million GWh to 9.4 million GWh during 1990-2012. Coal production increased from 1,053 million tons of oil equivalent (Mtoe) to 2,990 Mtoe in 2012 and coal imports have also increased, now accounting for over two thirds of the share of global coal imports. Natural gas production increased from 951 billion cubic metres (BCM) to 1,469 BCM.

Energy consumption in the Region is estimated at 6,781 Mtoe in 2013, dominated by coal at 45 per cent and followed by oil at 27 per cent, natural gas at 19 per cent, hydropower at 5.8 per cent, and nuclear power at 2 per cent. Non-hydro renewables, principally wind and solar at 1.3 per cent, have a low share of overall energy consumption. The Region produces 47 per cent of total world energy and so relies on imports to meet the overall demand, even though there are a number of energy exporters in the Region, including Australia, Indonesia, Islamic Republic of Iran, and the Russian Federation.

Figure 1.2 Regional GDP 1990-2012

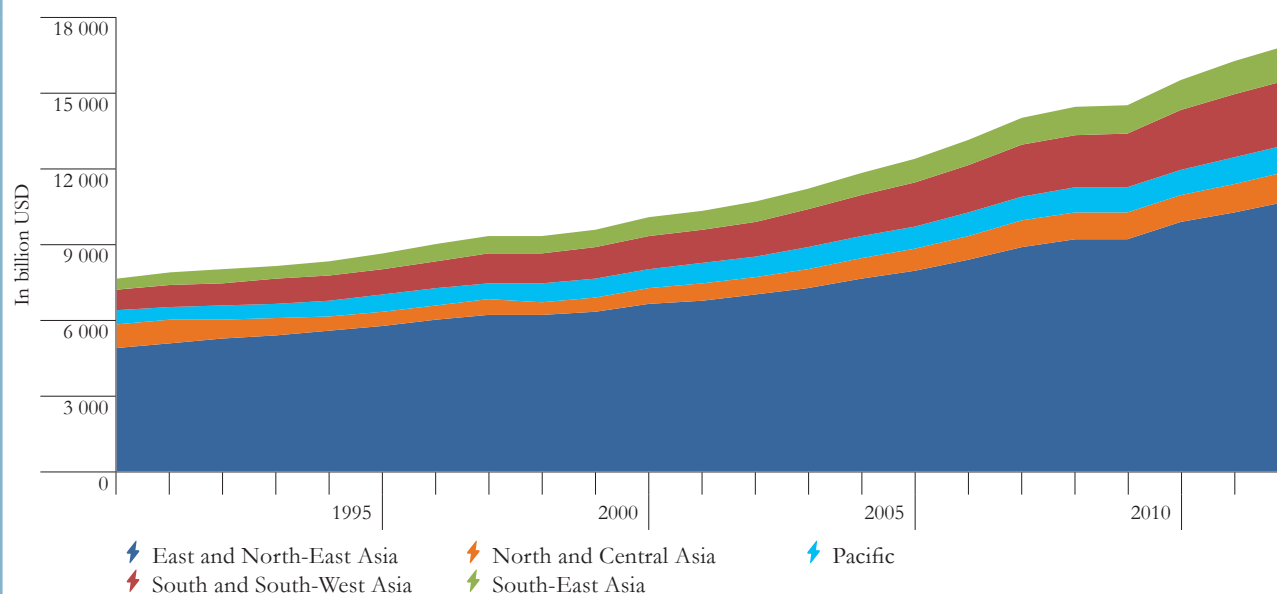
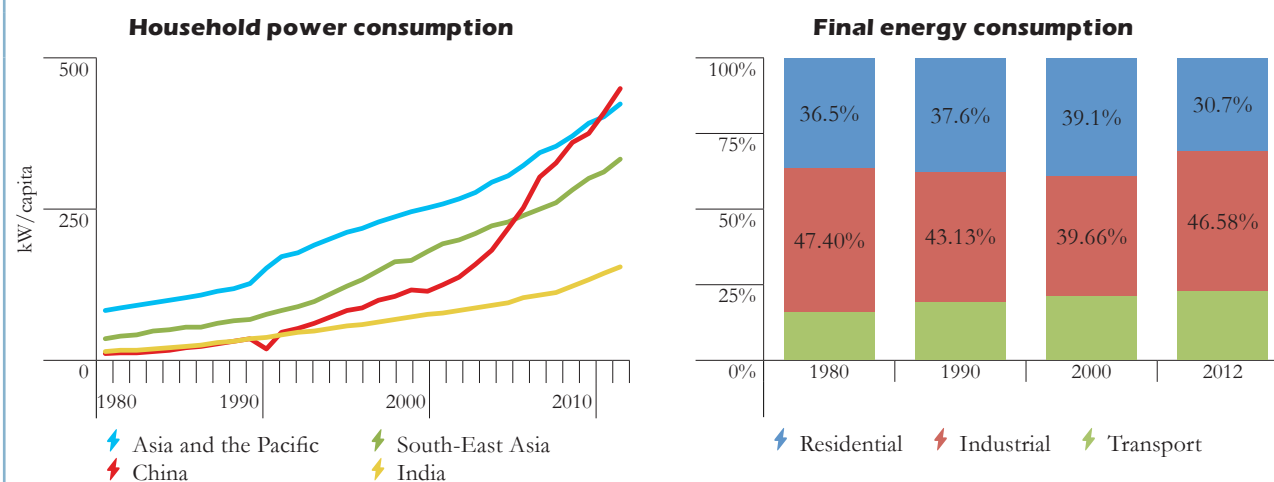


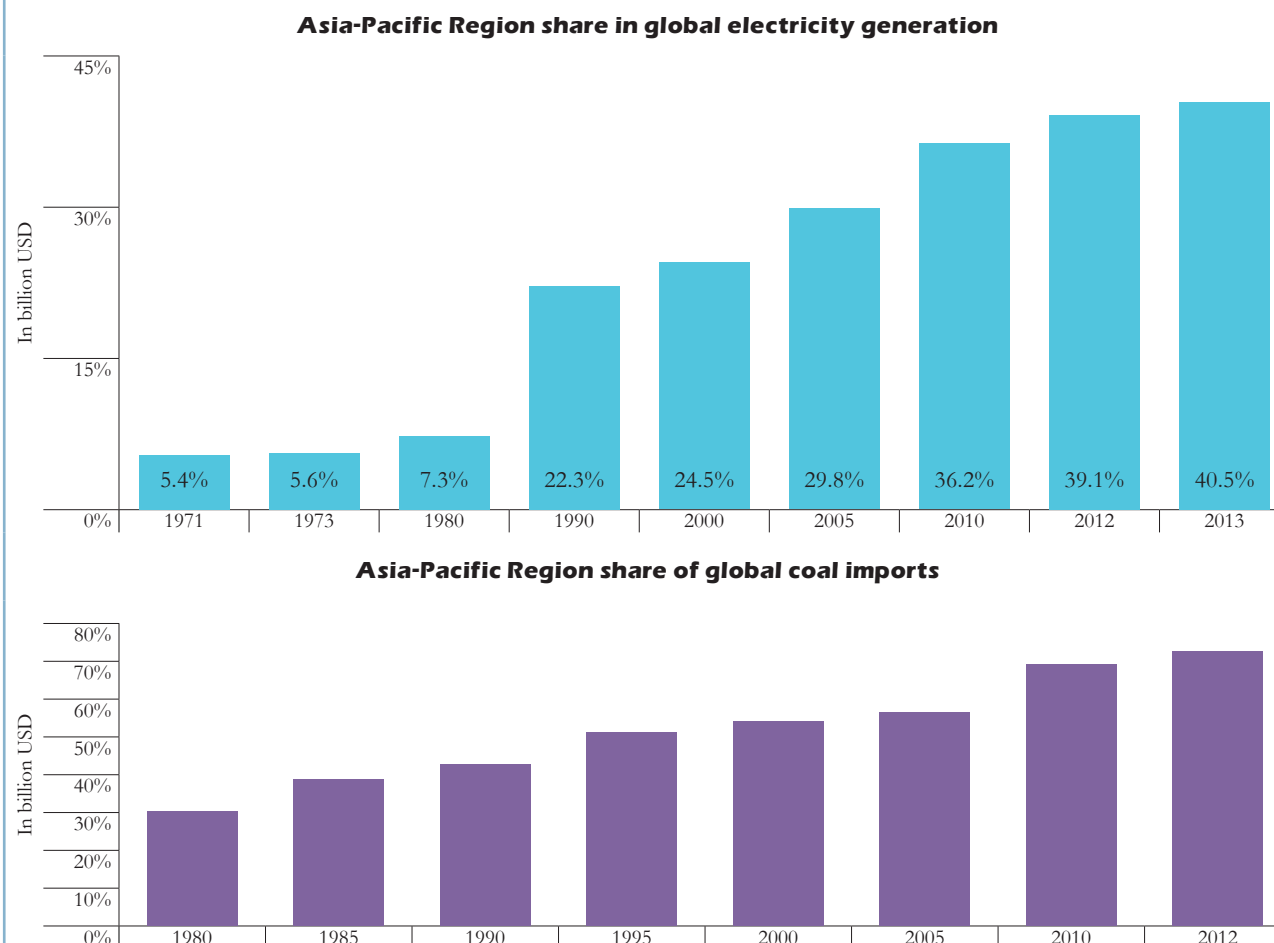
Table 1.1 Selected Indicators: Asia and the Pacific Region

Indicators	Units	East and North-East Asia	North and Central Asia	Pacific	South and South-West Asia	South-East Asia
Total GDP (billion \$)						
1990	2005 \$	4,885	955	540	844	444
2012	2005 \$	10,718	1,174	1,080	2,592	1,336
Population						
1990	Millions	1,359	215	27	1,246	444
2012	Millions	1,606.0	225	39	1,847	626
Per Capita GDP						
1990	2005 \$	3,594	4,451	20,203	677	1000
2012	2005 \$	6,747	5,257	28,818	1,440	2185
Total Final Energy Consumption/Capita						
1990	kgoe	782	3,618	3,238	327	403
2012	kgoe	1,386	2,571	3,353	496	690
Total Electricity Production						
1990	kWh/capita	1,198	6,163	6,948	368	348
2012	kWh/capita	4,171	5,845	7,766	989.7	1,236
Household Electricity Consumption						
1990	kWh/capita	168	559	2378	58	76
2012	kWh/capita	621	771	2723	200	335
Primary Energy Intensity 2005 GDP (PPP)						
1990	kgoe / 1000GDP	274	498	210	236	215
2012	kgoe / 1000GDP	220	349	159	175	185

Figure 1.3 Energy Consumption Trends



Source: www.asiapacificenergy.org.



Source: EIA data.

In terms of energy equity, 1.2 billion people still have no access to electricity, although 1.7 billion people in the world have gained access to electricity in the two decades since 1990. China has improved access to electricity for most of its population; however, the remaining developing countries in the Region still account for about half or more of the world's energy-poor population, both in terms of access to electricity and reliance on traditional biomass for cooking (Table 1.2).

The Region's energy imports have grown rapidly, from 525 Mtoe in 1980 to 2.2 billion Mtoe in 2012, accounting for an increasing share of total global imports (Figure 1.4). Compared to 1980, the Region's energy import share has nearly doubled, from 23 per cent to over 42 per cent in 2012. Compared to imports, overall exports have remained more or less stagnant at around one third of global energy exports since 1990. There has been a slight decline in the global share of Region's energy exports, from 36 per cent in 1990 to 35 per cent in 2012.

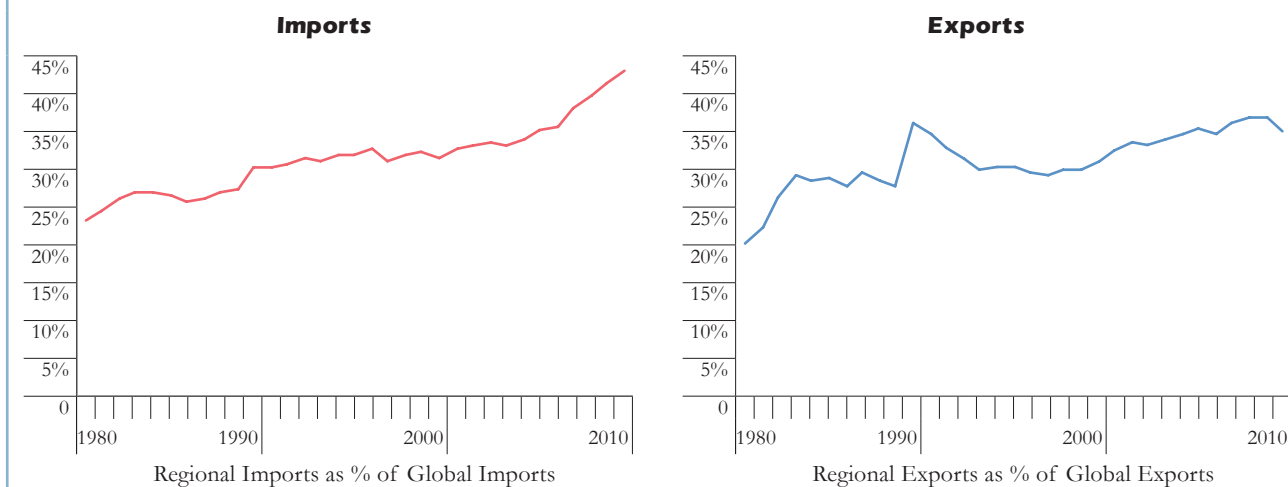
Coal is abundantly available in many locations and is of different grades, whereas oil reserves remain concentrated in a few countries of the Region. Of the estimated 892 billion tons of international coal reserves, approximately 55 per cent is within the Region. The largest deposits of this regional total

Table 1.2 Energy Poverty in the Asia-Pacific Region

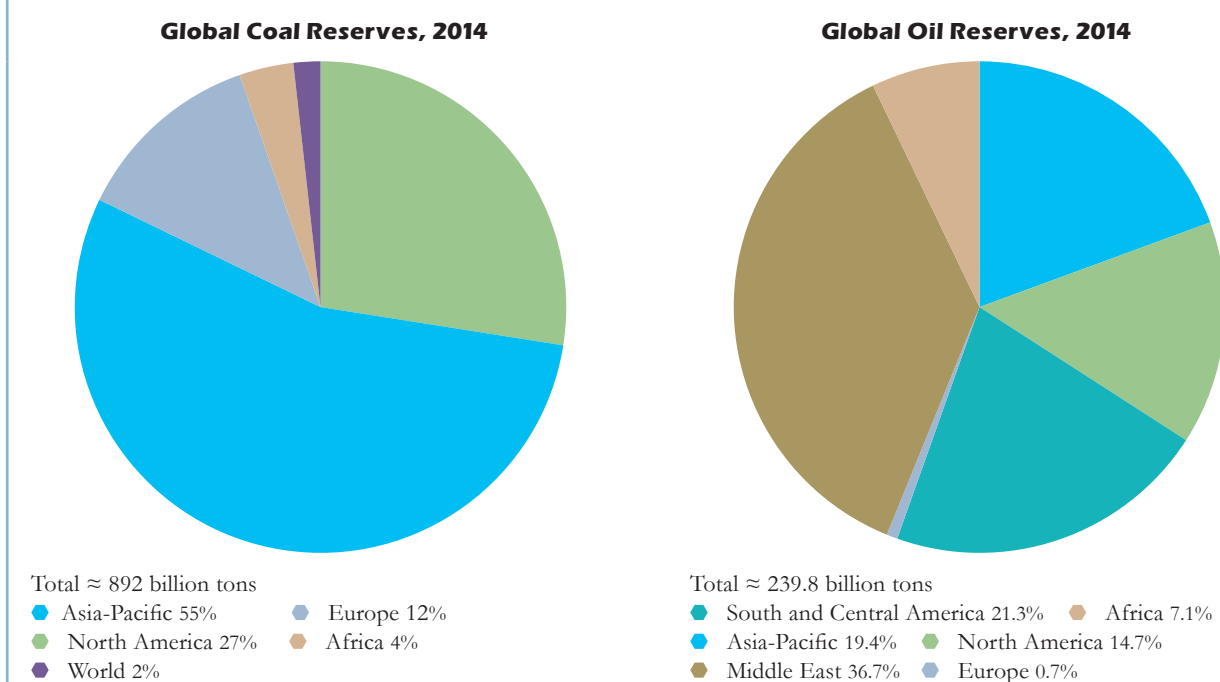
Country	Without Electricity Access (in Millions)		Population Relying on Traditional use of Biomass for Cooking-2013	
	1990	2013	Millions	%
China	65.4	1	450	33%
Democratic People's Republic of Korea	16.2	18	12	47%
Mongolia	0.4	0.3	2	63%
North East and East Asia*	84.6	19.3	464	--
Cambodia	10.3	10	13	88%
Indonesia	98.0	49	98	39%
Lao People's Democratic Republic		1	4	65%
Myanmar	45.3	36	49	93%
Philippines	9.5	21	53	54%
Thailand	10.9	1	15	23%
Viet Nam	19.0	3	42	47%
South East Asia*	193.0	121	274	--
Bangladesh	104.4	60	140	89%
India	579.1	237	841	67%
Nepal	19.5	7	22	80%
Pakistan	65.0	50	105	58%
Sri Lanka	7.4	1	15	74%
South Asia*	775.4	355	1,123	--
Other Asia*	10.9	31	32	75%
Pacific	5.7	8.0 [#]		
Total	804.1	526.3	1,893	51%
World	1286.4	1,201	2,722	--
Asia as % of the World	62.5%	43.7%	69.5%	

Source: World Development Indicator Database for 1990 and World Energy Outlook (WEO) Access Database for all other data. There are some minor discrepancies between these two databases, but the differences are minor and hence two different data sources are used. * Totals include access for other countries in the region. # Data pertains to 2012 and hence not included in the 2013 data total. WEO Database does not have detailed data for the Pacific Region.

Figure 1.4 Energy Trade and Reserves in Asia and the Pacific Region



Source: Asia Pacific Energy Portal data downloaded from <http://www.asiapacificenergy.org>.

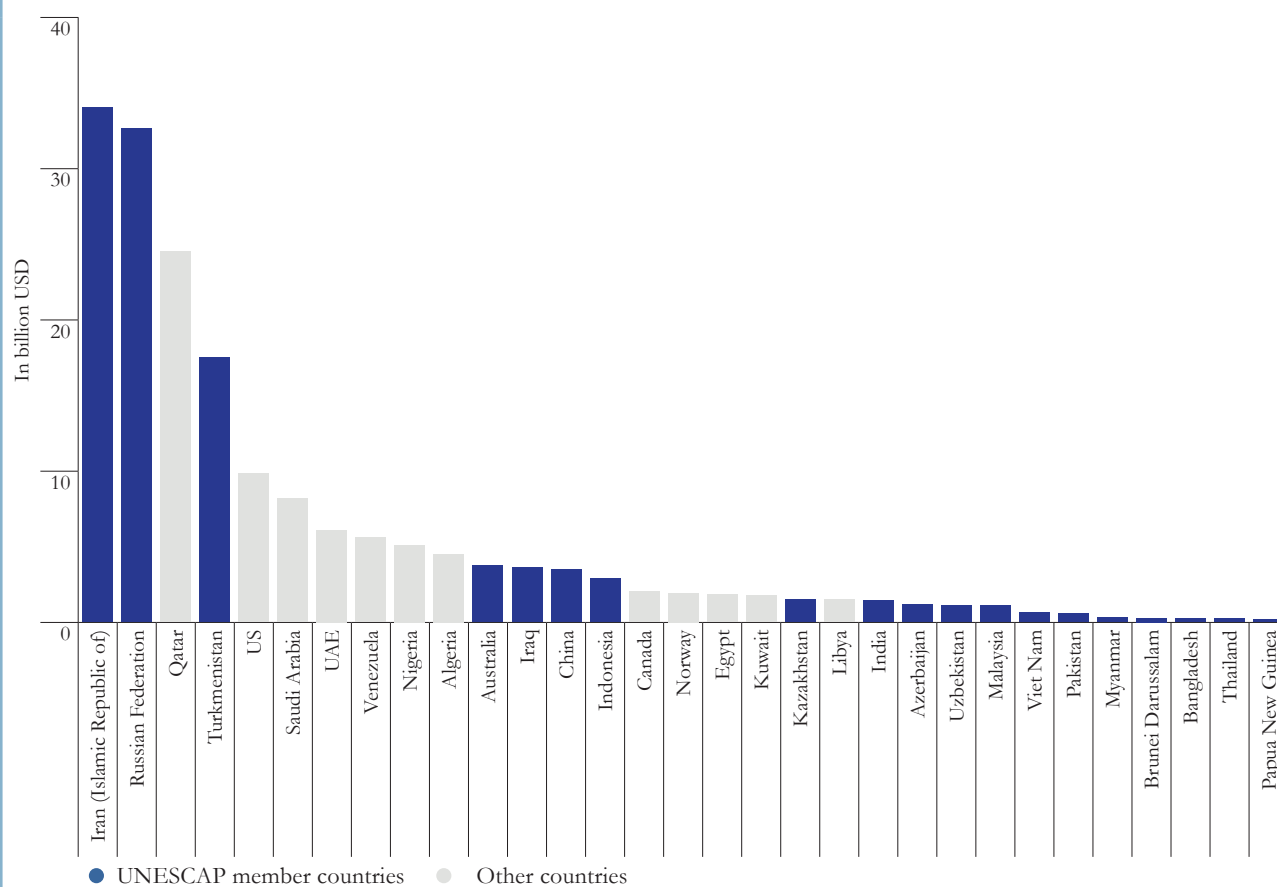


Source: British Petroleum Statistical Review of World Energy 2014.

are in the Russian Federation (32%), China (23%), Australia (16%), India (12%), Kazakhstan (7%) and Indonesia (6%).

Of the current total world oil reserves (approximately 1,700 billion barrels), the vast majority (39%) is located in the Middle East. By contrast and despite its size, the Region accounts for only approximately 20 per cent of global oil reserves, with the majority of this concentrated in the Islamic Republic of Iran (49%), the Russian Federation (29%), Kazakhstan (9%) and China (6%).

Figure 1.5 Proven Global Natural Gas Reserves



Source: BP Statistical Review of World Energy 2014

Natural gas has been rising in significance in recent decades as an alternative lower-carbon energy resource. It helps to diversify energy markets as a fuel that is increasingly competitive in the main end-use sectors, i.e. power and transport applications. Natural gas is more widely distributed than oil on a global level, but the bulk of proven reserves are still concentrated in terms of supply from the Middle East (Islamic Republic of Iran and Qatar), Central Asia (Turkmenistan), and the Russian Federation (Figure 1.5).

Historically, Russian gas exports were concentrated to markets in Europe and Central Asia; recently, an important shift has taken place, with Russian gas now being exported to China via pipeline and liquefied natural gas (LNG) to Japan (the Region's largest consumer of natural gas). China currently imports natural gas from the Russian Federation (81%) and other countries including Myanmar, Uzbekistan, and Kazakhstan, totaling approximately 31 billion cubic metres (BCM) in 2014. Thailand imported gas from Myanmar amounting to 9.7 BCM, whereas Indonesia exported 9.5 BCM through pipeline to Malaysia and Singapore in 2014. Asia is a major LNG importer, accounting for over 70 per cent of global trade or a total of 242.7 BCM in 2014. Japan, being a major importer, accounted for half of Asia's LNG imports at 120 BCM. Other major importers include China (27.1 BCM), India (18.9 BCM), and Republic of Korea (51.1 BCM). Intra-Asia LNG gas accounted for 114 BCM; other suppliers include the Middle East (101 BCM), with Qatar accounting for almost two thirds of Asian LNG imports.

Table 1.3 Overall Energy Imports and Exports: Asia and the Pacific Region

Units		1990	1995	2000	2012
Energy Imports					
Coal	Mtoe	148.9	147.1	181.7	487.3
Oil	Mtoe	563.1	694.4	834.9	1,291.1
Natural Gas	Mtoe	131.3	71.0	104.4	281.8
Electricity	Mtoe	9.0	5.0	4.7	6.9
Renewable energy (biofuels)	Thousand toe	75.0	29.0	38.0	153.0
Total	Mtoe	918.0	1,000.0	1,225.0	2067.3
Energy Exports					
Coal	Mtoe	149.5	165.3	247.1	568.2
Oil	Mtoe	624.9	547.9	620.0	910.3
Natural Gas	Mtoe	313.3	238.1	269.1	326.6
Electricity	Mtoe	8.8	6.0	5.0	6.8
Renewable energy (biofuels)	Thousand toe	86.0	134.0	85.0	1,890.0
Total	Mtoe	1,097.0	957.0	1,141.0	1,814.0

Mtoe: million tons of oil equivalent; toe: ton of oil equivalent

Source: Asia Pacific Energy Portal downloaded from <http://www.asiapacificenergy.org>.

In terms of overall energy trade, the Region that was a net exporter of energy until 1990 has now become a net importer (Table 1.2). It will continue to depend on fossil fuels, and its dependence on Middle East oil is likely to increase in years to come. Although the Region is connected to the global economy in terms of overall share of global trade at 37 per cent, energy trade remains insignificant by comparison. Imports of fossil fuels have grown over time, whereas exports indicate mixed trends. Though the recent trends in renewable energy trade are encouraging, exports of electricity and natural gas have remained largely stagnant and significantly below their potential. The Region is now particularly dependent upon oil supply from the Middle East. Oil demands from countries like China (45%), India, (61%), Japan (73%) and Singapore (36%) are met from the Middle East,⁶ which makes the Region particularly vulnerable in terms of over-dependency on a single geopolitical region and the shipping bottleneck and associated risks of supply disruption in the Strait of Hormuz⁷ — where an estimated 85 per cent of oil shipments are destined for Asian markets.⁸ Further, the supplies to South-East and East Asia are subject to the bottleneck in the Strait of Malacca.⁹ Diversifying the energy sector is, therefore, an issue of significant strategic importance in terms of ensuring adequate protection from oil supply shocks. It is also important to enhance regional trade of electricity and natural gas in order to reduce dependence upon oil, which is becoming a development imperative for the Region.

Climate Change and Environmental Challenges

The Region is expected to remain dependent on oil, as the mobility and transport of goods and people is critical for economic development. Transport is currently heavily dependent upon oil, which is also the fastest growing source of global carbon emissions. Given the growing middle class¹⁰ and rapid urbanization in the Region, overall oil demand for personal mobility and transportation of goods is expected to rise significantly. For example, according to World Energy Outlook (WEO) forecasts, China's passenger transport fleet is expected to grow at a remarkable rate, with penetration of passenger light

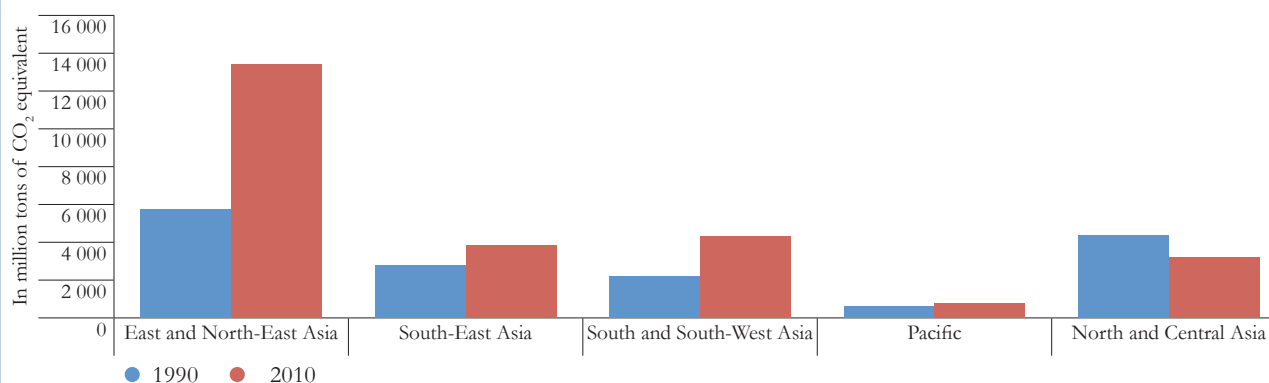
duty vehicles rising from around 70 vehicles per 1000 population to 360 vehicles by 2040, thus raising oil use in transportation from 4.7 million barrels/day (MBD) to 9.2 MBD.

The transport sector is a major contributor to carbon emissions, accounting for 23 per cent of total CO₂, besides generating local pollution, noise and road congestion. The major challenge for the Region's policymakers is to work on a policy of urbanization that will reduce the negative impact of the growing transport sector on the overall sustainable development agenda. This is particularly important because "transport and housing are embedded goods" and decisions regarding one are highly dependent on the other.¹¹ It is important to integrate transport and urban planning in order to move towards decarbonizing. This is a major challenge because policy and planning at government level is often fragmented between institutions in charge of transport and other complementary urban policies (e.g. land use) or entities in charge of the different modes of transport. There are also often various levels of government with jurisdictions on the same aspect and there are contradictions or lack of coordination among government agencies.

The energy sector accounts for a major share of overall greenhouse gas (GHG) emissions, with coal alone generating 60 per cent of the global total. This is likely to continue to present an important challenge into the future. There has been a large increase in GHG emissions in the Region, at 62.5 per cent in the period from 1990 to 2012 against the global increase of 30 per cent. East and North-East Asia account for the largest increase, of 134 per cent, whereas North and Central Asia have been able to reduce GHG emissions by 27 per cent. With large increases expected in energy use in the next few decades, Asia will need to work on an effective transition to cleaner energy sources and enhanced energy efficiency.

Overall, the Region's energy outlook is challenging and in order to transition to a sustainable development path, it must deal with the barriers to developing a clean energy system. This is crucial because the Region has grown at a fast rate for a long period, bringing sustainability issues to the forefront. While there is much more prosperity, cities have a high level of pollution, the health impact of which is estimated to be between 9 per cent to 13 per cent of the GDP in China and 5 per cent to 7.5 per cent of GDP in India. There is a realization that unless sustainability issues are integrated in overall energy planning, the Region will face serious environmental challenges. The current model of development carries with it a growing risk of locking in a high-pollution, high-carbon path. Current economic and

Figure 1.6 Greenhouse Gas Emissions



Source: ESCAP (2014) *Statistical Yearbook 2014 Table 19.1*

poverty reduction gains may prove unsustainable in the long run, as rapidly rising GHG emissions result in serious climate damage which will affect poor people much more adversely.

In recognition of this reality, 42 countries in the Region have submitted Nationally Determined Contributions (NDCs) to the UN Framework Convention on Climate Change. All but 7 countries have included GHG reduction targets. Under the NDCs, Bangladesh, Bhutan, Indonesia, Kazakhstan, the Philippines, Tajikistan, Thailand and Viet Nam have undertaken to reduce absolute levels of emissions from the business-as-usual levels, whereas China, India and Malaysia have also pledged to reduce emission intensity. China, India, Lao People's Democratic Republic and Papua New Guinea have plans to increase the share of renewable energy in their overall energy mix. Cambodia, Lao People's Democratic Republic and Sri Lanka have plans to increase forest cover. The leadership of the Region is highly aware of the need to integrate environmental responsibilities into their national action plans.

The adoption of the Paris Agreement on climate change in 2015 has provided a framework for global action on climate change, including agreement to constrain global warming to below 2 degrees Celsius and a commitment to mobilize at least \$100 billion of climate finance annually. But this may not be enough, and member States will need to undertake increasingly ambitious efforts to decarbonize their economies and adapt to the effects of climate change. Given the dominant role of the energy sector in driving emissions, member States in the Region will be examining opportunities for emissions reductions in the energy sector in order to meet their climate change commitments. The climate dimension adds a further strategic driver for countries to support enhanced energy connectivity, particularly where it enables greater utilization of gas to support a shift from coal and greater exploitation of renewable energy. Regional integration and energy connectivity are seen as important policy tools for reducing dependence on fossil fuels and diversifying sustainable sources.

It is expected that by 2050, two thirds of the global population will

Box 1.1 Low Carbon Urbanization

reside in urban areas and 90 per cent of this increase will be in Asia and Africa. India and China are expected to grow by close to 700 million people and urbanization in Asia is creating mega-cities and very large energy demand centres. Growing concern regarding the environment also requires these centres to meet the challenges of high levels of pollution mostly linked to high-density of vehicular traffic and thermal power stations located in the vicinity of cities. Some of the actions initiated by governments include use of clean transport fuels (compressed natural gas), promoting electric and hybrid vehicles, increasing capacity of public transport that also uses clean fuel or electricity, and closing old thermal power plants.

Energy connectivity, particularly increased trade of gas and electricity from hydropower projects, will provide new and additional energy resources that benefit urban regions. However, it is the development of "smart grids" that is expected to improve conditions in large urban centres. These deploy advanced computer-based two-way communication for matching demand and supply. On the supply side, this helps integrate intermittent solar and wind generation, some of which will be small, distributed capacity located on the premises of the consumers. On the demand side, it allows customers to reduce demand when supply gets constrained, typically by marginally lowering air-conditioning load without causing real discomfort to people. More importantly, it will help integrate electricity storage, which will get a boost when large fleets of electric vehicles become available in urban centres. The knowledge-sharing component of regional energy connectivity can accelerate the development of smart grid technologies, and close collaboration of utilities and suppliers will help develop robust supply chains for the smart grid components so benefits can be shared by urban centres that may be less technologically advanced.

The Challenges to Regional Energy Connectivity

Asia's dynamism stems from its intricate web of regional supply chains and global production networks. For the last four decades, the Asia-Pacific Region has transformed itself into a global manufacturing hub; this has been possible due to success in connecting to global production networks and supply chains largely driven by advances in information technology, declining transport costs and falling trade

barriers across countries. Most of the process was market-driven, as major relocation of production capacity took place to take advantage of lower labour costs enabled by foreign direct investments. These Asian production networks essentially became self-reinforcing, bolstering investments and fostering transfer of technology. Asia's diversity emerged as its main strength and the resulting production integration provided it with a vital new comparative advantage in the global economy. Where markets lead, governments usually

follow and, in reality, these production networks have become a major force to integrate Asian markets in many different ways. Intra-regional trade in the Region is still low; it accounts for only 56 per cent, compared to the European Union, where it is estimated at 64 per cent.¹²

Unlike the global production networks that created a positive force for reinforcing the bottom-up market integration process, efforts to connect the energy sector in the Region have not been very successful as yet, excepting some cross-border investments in energy projects. Trade and investments in regional energy networks remain low despite the fact that there is a high and growing demand for energy and there are beneficial opportunities waiting to be tapped from regional energy trade. A number of factors are responsible for this disconnect, as described below.

- i. One element is the fact that networks, unlike commodities with their special attributes, make it difficult to trade easily.¹³ Physical energy networks, be they gas pipelines or transmission grids, are capital-intensive and generally subject to economies of scale. Most of these networks not only have lumpy investments but are also of little use unless they are completed and maintained in good condition. With large sunk costs, energy networks present major challenges in financing and



Two defining challenges of our century are: overcoming poverty and managing climate change. If we fail on one, we will fail on the other.

Nicholas Stern¹²

maintenance, especially when they have to traverse many countries. These capital attributes lead to many market and government failures, and private investors are reluctant to enter such risky areas.

- ii. Unlike normal goods or commodities, most networks are space-specific: once a location is set, it cannot be moved. For example, once a gas pipeline is laid, the spatial dimensions will also have an impact on value creation for one group of people versus another. It is difficult to establish compensation mechanisms even when they are within single national boundaries; when they are under different legal and national systems, it creates political risks and aversion to investment.
- iii. Energy demands are relatively inelastic because it is difficult to find appropriate substitutes for power or fuel for transport. Any disruption in service will affect a large population and may not be tolerated. Underlying domestic or local politics are significant and this becomes a major challenge for promoting energy integration.
- iv. When energy markets are predominantly state-owned, investments from private savings are difficult to come by. The underlying institutional, regulatory and policy frameworks are not conducive to large-scale private investments. There are large transaction costs involved in preparing and processing cross-border energy projects. It also takes a very long time for a project to move from an idea to the drawing board to actual implementation. Unless a level playing field is created, the private sector is reluctant to invest in such projects.
- v. Commodity trade has largely been initiated by multinationals, with well-defined value chains for the entire production process, but the overall benefits of better power connectivity, for example, remain less clear.
- vi. With clear economies of scale and scope, regional commodity clusters have grown for most products and the stakeholders have benefited from such integration in a relatively short period of time. However, the payback period for energy connectivity is long and uncertain.
- vii. Lack of physical capacity and creditworthiness of state enterprises also inhibit energy connectivity, as getting payment is perceived by investors to be a major risk. Different legal and regulatory capabilities and lack of transparent governance of the sectors pose major challenges for cross-border investments.
- viii. There are large positive and negative externalities inherent in energy connectivity so rules and regulations need to be in place, not only for ensuring a fair distribution of costs and benefits among stakeholders, but also for those who gain to suitably compensate those who lose in the global economic space.¹⁴ Invariably, there are problems of measurement, and policy regimes must be designed that can fully address these externalities, determining compensations for those affected negatively, and identifying benefits from large investments in energy networks. Moreover, the energy integration process is not limited simply to creation of physical links across the region. It requires a series of policies and regulations for facilitating different types of flows inherent in this process.
- ix. Balancing the gains with overall costs between different groups of stakeholders requires a robust institutional mechanism. This requires intervention and leadership by the member governments and technical experts if regional energy connectivity is to happen.

- x. Various existing subregional programmes supporting the energy integration process in the region show a lack of consensus in defining a comprehensive model of integration and satisfying the interests of the entire Region — States as well as all groups of stakeholders. To a great extent, this demonstrates the lack of human and institutional capabilities, political leadership, and market mechanisms.
- xi. Human resource capacity is one of the key factors influencing what regional institutions can actually do. The European Commission—the heart of the European Union (EU) administration—employs over 23,000 people in total; the two Directorates for Environment and Climate have staffs of 454 and 137, respectively; the European Environment Agency, which deals mainly with monitoring and information brokerage, employs around 200; and a number of environmental research centres are also part of the EU administration, adding further expertise and capacity. While a comparison of the secretariat capacity of the EU and the Association of Southeast Asian Nations (ASEAN) is perhaps unfair, given that they have different mandates, it is notable that ASEAN's secretariat employs just over 300 people and the department dealing with environmental issues has fewer than 10 staff members. As a further comparison, the secretariat of the Council for Environmental Cooperation (the organization set up as part of the North American Free Trade Agreement (NAFTA) to facilitate coordination of environmental protection in the three countries) employs fewer than 50.
- xii. Finally, energy security issues are of prime importance to political leadership and it was widely believed that national energy security would be compromised by regional energy trade that creates import dependency on neighbouring countries. Political and policy mindset was thus working against regional energy connectivity until very recently. This will have to change if energy connectivity is to take root in the Region.

For the first time, favourable market conditions are being created in terms of economies of scale and scope, especially for large-scale distributed and renewable energy systems to be integrated with the traditional power networks. Because large economies have been able to reduce the cost of some of the renewable energy options and Asia has good production and supply chains, a level playing field has been created for solar and wind energy. It is possible for private investments to flow in if the regulatory barriers for energy trade are removed. What is needed is to replicate the success of global supply chains for the energy sector and the market can jump-start the process of connectivity and integration, as so many important drivers of energy connectivity are already present in the Region.

Drivers of Regional Connectivity

1. Regional Mandates for Enhanced Energy Connectivity

A number of countries and subregions consider energy connectivity to be a clear option for dealing with current energy sector challenges and still achieving sustainable development. Both political leaders and policymakers have committed to connecting energy networks, as is evident from the selected regional mandates summarized in this section.

Association of Southeast Asian Nations (ASEAN): Energy consumption by the South-East Asian nations is expected to more than double over the next decades. ASEAN faces the challenge of finding the

right balance between energy security, environmental sustainability, and economic competitiveness. The ASEAN Plan of Action for Energy Cooperation (APAEC) 2010-2015 served to advance cooperation towards energy security. The subregion has made good progress on several of its goals; six of the 16 planned interconnections under the ASEAN Power Grid and 12 bilateral gas pipeline interconnections have been commissioned. This work will continue under the APAEC 2016-2025 presented in October 2015; under the theme of “Enhancing Energy Connectivity and Market Integration in ASEAN to Achieve Energy Security, Accessibility, Affordability and Sustainability for All”, this plan provides enhanced goals and targets for the subregion.

Asia-Pacific Economic Cooperation (APEC): At the October 2015 APEC Energy Ministers meeting, instructions were given to move towards an energy-resilient APEC Community, by promoting energy trade and investment frameworks to enhance regional energy security and ensure sustainable economic growth. Using APEC as an ideal forum to explore the concepts of cross-border energy trade and renewable energy in a non-binding manner, a priority goal for developing a resilient APEC community will be to provide energy access to people, including those in remote communities, so as to generate economic growth. The APEC Business Advisory Council was expected to foster and nurture public-private partnerships so as to encourage the adoption of appropriate standards for critical energy infrastructure. Finally, APEC economies were encouraged to support the work of the newly established APEC Sustainable Energy Centre in expanding sustainable city development across the region, promoting cutting-edge clean energy technologies and fostering other programmes on energy resiliency.

Greater Mekong Subregion (GMS): The GMS has been successful in promoting energy trade among the economies of the subregion and creating harmonized policy and institutional mechanisms for the power sector. At a recent meeting, the Ministers welcomed efforts to advance energy cooperation by using regional resources fully in a sustainable manner, extending power grid connections in the GMS and collaborating on the development and supervision of a subregional power market. The subregion is in the process of selecting the host country for the Regional Power Coordination Centre (RPCC), the permanent institution owned by all GMS countries for enhancing regional power trade and implementing regional power interconnection initiatives.

South Asian Association for Regional Cooperation (SAARC): In order to promote cooperation among the SAARC member States, the Islamabad Declaration of the Twelfth SAARC Summit, held in January 2004, mandated South Asian energy cooperation, including the concept of an energy ring, a common regional highway of energy within and across the region for the movement of energy (including both commodity and services) in a market-based environment that would benefit all participants. The leaders at the 18th SAARC Summit in 2014 emphasized the need for linking South Asia with contiguous regions, including Central Asia and beyond, by all modes of connectivity and they directed relevant authorities to initiate national, regional and subregional measures and necessary arrangements. Signing the framework agreement for cooperation in the power sector, which will ensure electricity trading through grid connectivity, the leaders directed the relevant SAARC bodies and mechanisms to identify regional and subregional projects in the areas of power generation, transmission and power trade, including hydropower, natural gas, solar, wind and biofuel.

Central Asia Regional Economic Cooperation (CAREC): CAREC’s mandate is to help its member countries — mostly vast, landlocked areas with small, scattered populations — to build the trade, transport and energy links that are necessary to promote economic development and reduce poverty. The CAREC Ministers endorsed an energy strategy in 2008 that provides the framework for energy cooperation. Its vision is to ensure: (i) energy security through balanced development of the region’s energy infrastructure and institutions; (ii) stronger integration of the region’s energy markets; and (iii) economic growth through

energy trade. The Energy Work Plan (2016-2020) identifies six elements with monitorable indicators, namely: (i) developing the Central-South Asia Corridor; (ii) promoting regional electricity trade and harmonization; (iii) managing energy-water linkages; (iv) mobilizing financing for priority projects; (v) capacity-development and knowledge-management; and (vi) promoting clean energy technologies.¹⁵

Eurasian Economic Union (EAEU). The 2014 treaty of the Eurasian Economic Union brings together Armenia, Belarus, Kazakhstan, the Kyrgyz Republic and the Russian Federation. It provides for free movement of goods, services, capital and labour, and pursues coordinated, harmonized and consistent policy in the sectors determined by the treaty and international agreements within the Union. Among activities in various areas, the treaty explicitly mandates gradual creation of common markets for oil and petroleum products, gas and electricity. Protocols attached to the treaty also explain that members will allow access to infrastructures that are natural monopolies, i.e. pipelines and transmission lines.¹⁶

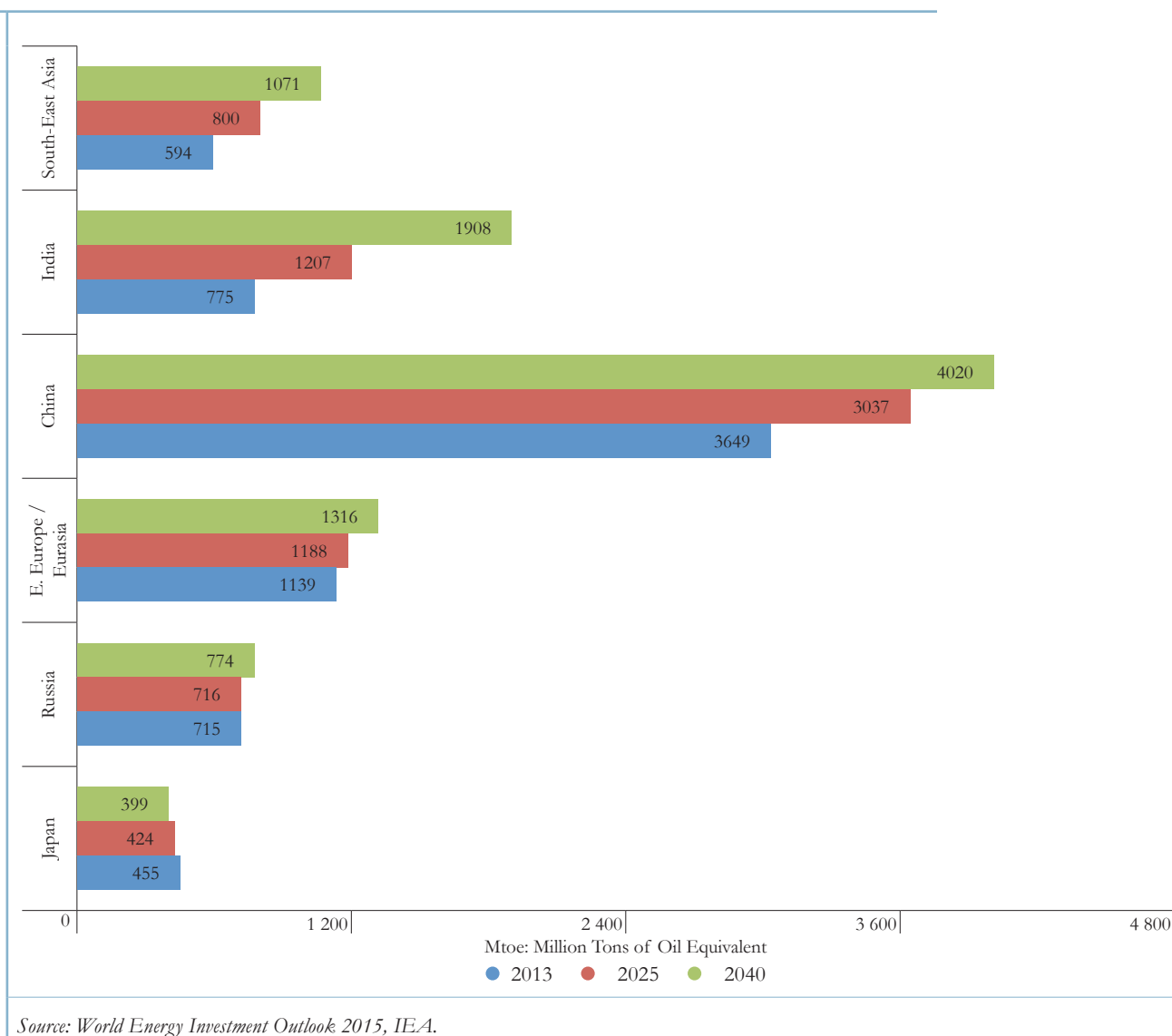
Economic and Social Commission for Asia and the Pacific (ESCAP): At the 68th Session of the Commission in May 2012, the secretariat was asked to identify options, in consultation with member States, which member States may choose regarding regional energy connectivity. This included an intergovernmental framework that could be developed for an integrated regional power grid, which could be termed the “Asian Energy Highway”, an analysis of the socioeconomic and environmental benefits, as well as the challenges and opportunities, inherent in the realization of each option. A declaration at the 2013 Asia Pacific Energy Forum included a request of member States to promote an Asia Pacific Energy Security Cooperation Framework. This initiative, which includes a trans-Asian energy system, will help to ensure both the near- and long-term energy security of the Region. It will connect producers and consumers of energy resources and facilitate new markets for clean and efficient energy technologies. Its goal is to shift development to a low carbon path while ensuring universal access to energy within a predictable time frame.

2. Development Agenda and Rising Energy Demand

Countries in Asia and the Pacific region have transformed their economies, making remarkable progress in raising incomes and living standards, becoming a vibrant manufacturing hub for the world, creating millions of jobs and improving overall access to services. Rapid economic growth of the Region translates to rising energy demands, both to sustain the large and growing production economy as well as to support direct energy consumption. As incomes rise, the population moves up the energy ladder, with significant impact on the environment. Similarly, though the Region has made impressive progress in eliminating poverty for millions, there still is a very large pool of energy-poor people in the Region. Overall demand for energy (Figure 2.1) is expected to grow significantly for three reasons: to support economic growth; to meet the demands of an ever larger and growing middle class; and to provide universal access to energy.

Several projections have been made about energy futures and though actual numbers may vary, the directions of all are very similar. The latest projection by the International Energy Agency (IEA) under its new policies scenario predicts global energy demand to grow by 37 per cent by 2040, with the majority of that demand growth predicted for Asia and the Pacific Region. These projections note dramatic shifts in regional energy demand, with energy use expected to remain essentially flat in much of Europe, Japan, Republic of Korea and North America, and conversely to rise in the rest of Asia (60% of the global total), as well as increasing at a slower pace in Africa, the Middle East and Latin America. Thus, the Region will be the frontrunner in global energy consumption. In absolute terms, China is expected to lead global energy consumption by 2030; by 2040, India's energy demand will be

Figure 2.1 Demand for Energy (in Mtoe)

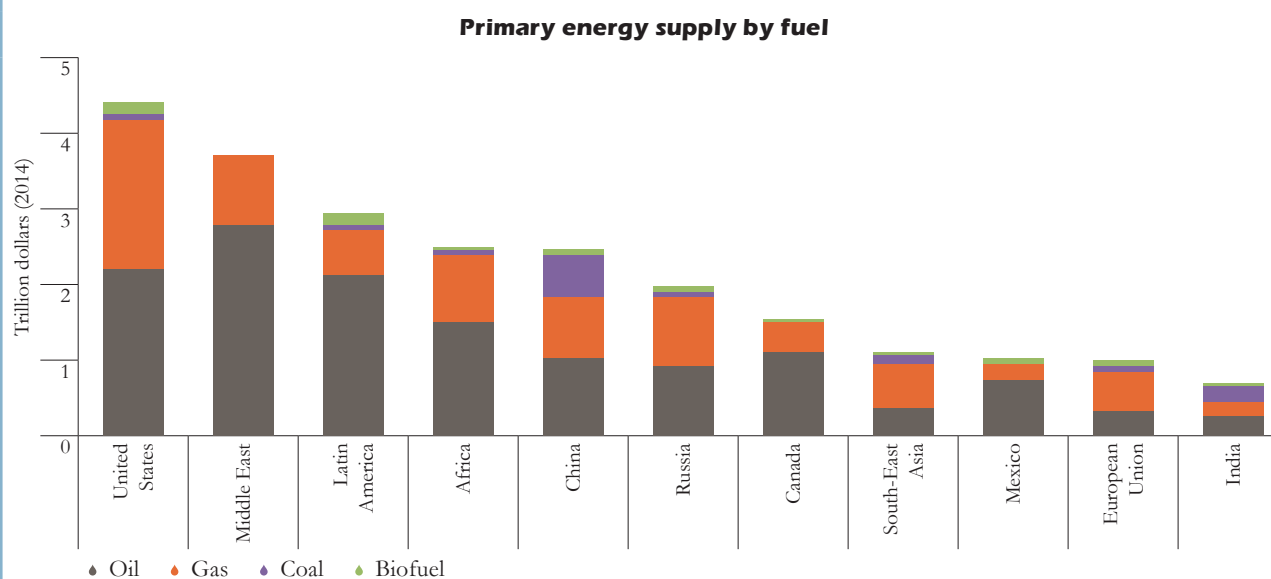


as large as that of the United States of America and is expected to contribute more than any other country — around one quarter of the total — to the projected rise in global energy demand.

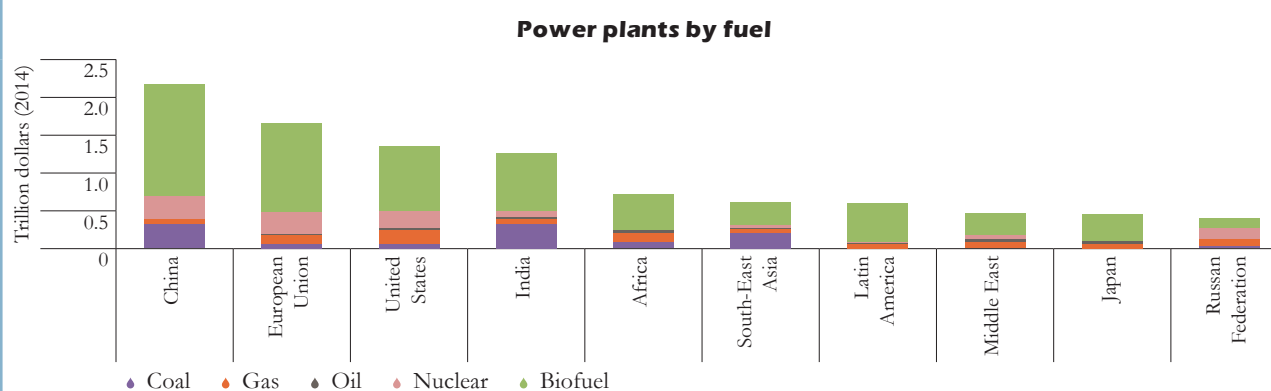
These shifts in demand are reflected in projections for energy investments (Figure 2.2). The Region is expected to account for over 40 per cent of the \$68 trillion cumulative energy investment between now and 2040. Of this, \$22 trillion will be needed for investments in energy efficiency. It is expected that two thirds of projected investments will be in non-OECD countries and in Asia, about half of which will be required in the power sector (i.e. generation, transmission and distribution) to fill much needed demand and access gaps. Such investment trends are especially important in considering opportunities for strategic regional energy development and connectivity initiatives.

The largest growing markets, China and India, will require over 60 per cent and 70 per cent of their respective energy investments to be in the power sector. A significant divergence from this general trend is projected for Central and Northern Asia, where countries like the Russian Federation would

Figure 2.2 Cumulative Investments in Energy 2015-2040



Source: www.asiapacificenergy.org.



Source: *New Policy Scenario, World Energy Outlook 2015, IEA.*

focus 40 per cent of investments on developing natural gas markets, and a similar outlook is anticipated for Australia in the Pacific region. The power sector is, therefore, expected to become a key focus for new infrastructure in the coming years and opportunities for maximizing long-term efficiencies in development and cooperation are more likely to be in this sector.

3. Resource Diversity

The Region is one of the most diverse regions of the world. Trade is always beneficial when countries are diverse. Table 2.1 presents energy reserves of the Region compared to the world and the share of the top five countries with respect to oil, natural gas and coal. Most resources are highly concentrated in a few countries, accounting for over 85 per cent of the ESCAP region. Thus, one of the main drivers of the energy regional connectivity is the need to develop energy resources. There is adequate demand in the Region; the overall energy consumption level in nearly all countries is low but growing at very high rates.

Table 2.1 Energy Resources and Production

	Unit	World	ESCAP All Countries	ESCAP Top 5 Countries
Crude Oil Reserves	million tons	224,904	43,441	40,279
Natural Gas	billion cubic metres	190,659	106,356	93,494
Coal	million tons	888,866	492,218	442,115
Electricity Production	Tera Watt-hour	23,307	9,432	8,192

Source: ESCAP (2015), *World Development Indicators* and www.asiapacificenergy.org

In its latest global assessment and comparison of energy technologies, the International Renewable Energy Agency (IRENA) showed that the levelized cost of energy for biomass-based power, hydropower, geothermal energy and onshore wind are all now competitively positioned in comparison to fossil fuel-fired power generation, subject of course to the local context and capacity constraints. Furthermore, the cost for solar photovoltaic power has also halved between 2010 and 2014, making it increasingly competitive at the utility scale.

Such developments are especially encouraging for the Region, given the large availability of solar, wind and other renewable energy resources.¹⁷ Solar resource availability is high over much of Southern and South-Eastern Asia, the Pacific, North and North-East Asia and the Gobi desert region. Wind resource is also widely available across the Region to enable large-scale development. With technological advances and reduction in costs, these resources present promising opportunities.

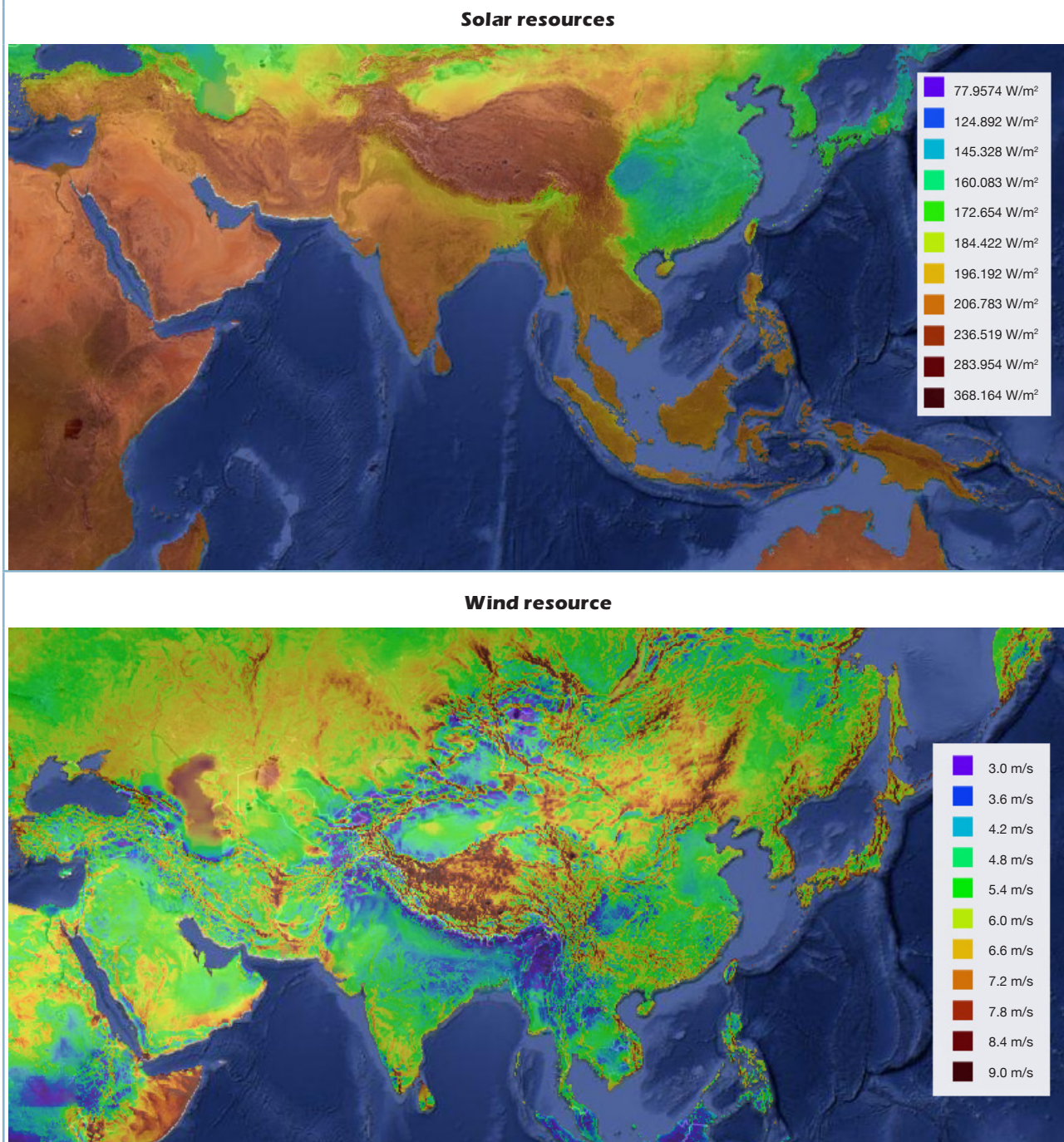
4. Sustainable Energy for All

The concept of Sustainable Energy for All (SE4ALL) has three elements: universal access, energy efficiency and renewable energy. Most of the action on universal access has to be focused at individual household level; provincial and national governments and utilities are the key players for this connectivity. However, regional cooperation will help some countries in the Region that have weaker capacity to enhance energy networks and thus improve energy access.

Some countries have border regions that are far from the economic centres and in such cases cross-border energy connections can be a cost-effective and efficient option for improving energy access. This option is made possible by eliminating trade restrictions on energy and providing incentives for expanding energy networks beyond national borders. Regional cooperation can thus directly contribute to meeting the SE4ALL goal of universal energy access. There are other channels as well; for resource-rich countries, regional cooperation and enhanced energy connectivity have a positive impact on exports and government revenue and reduce domestic supply costs due to economies of scale and scope. For energy-importing countries, additional supplies resulting from regional cooperation help in the shift to cleaner sources such as natural gas or renewables.

There is much to be gained from regional cooperation for the remaining two elements of SE4ALL as well — energy efficiency and renewable energy. In a large number of countries in the Region, new capital stock is being created now and it is important to ensure that efficient technologies are employed, through advocacy, awareness campaigns and knowledge-sharing; cooperation between countries with similar issues will hasten the deployment of new technologies. Very often the investments in individual energy efficiency and distributed renewable energy projects are small, and a regional approach will help create a large, consolidated regional investment programme that is easily replicable across countries. Aggregating small investments across the region will lower transaction costs. The region presents many

Figure 2.3 Renewable Resources



Source: IRENA *Global Atlas for Renewable Energy* (3TIER's *Global Solar Dataset*) and (3TIER's *Global Wind Dataset*).

Disclaimer: The boundaries and names shown and designations used on this map do not imply official endorsement or acceptance by the United Nations.

opportunities; regional energy efficiency programmes can cover improvement of power plant efficiency, commercial and public building energy efficiency upgrades, strengthening energy service companies, distribution of efficient light bulbs, and enforcement of efficiency standards and labeling regulations. Similarly, large regional programmes for renewable energy can be designed as special purpose funds, which can lower the risk and increase investment in small hydropower, solar, commercial biomass and

clean cooking fuels; diversion of part of the benefits from energy connectivity infrastructure projects will boost these funds.

Another option is creating multi-country, multi-investor initiatives for integrated subregional power transmission and gas networks that require large capital investment. To ensure the effectiveness of such a programme, a long-term planning horizon should be used — keeping in mind that decisions and changes made in one area will have ripple effects on optimal investment elsewhere. Multilateral development agencies would need to finance a significant part of the required investment — including technical assistance for institutional and regulatory reforms, as well as management and accountability systems. Regional programmes aimed at energy efficiency and renewable energy can go a long way to channel investments in these vital areas.

5. Energy Security

Under existing policies, the Region's energy growth will be accompanied by an increasing dependence on the Middle East for oil; Asia is expected to import two out of every three barrels of crude oil traded internationally by 2040. China is expected to overtake the United States as the world's largest oil-consuming country by 2030, whereas South-East Asia will gradually transition from being a net exporter of oil into being a net importer. Furthermore, India will play an increasingly dominant role in the international energy scene. According to IEA projections, India is expected to overtake the United States as the world's second-biggest coal consumer before 2020, and soon after to surpass China as the world's largest importer of coal. China, India, Indonesia and Australia are expected collectively to account for over 70 per cent of global coal output by 2040.¹⁸ Such concentrations of energy demand and supply frontiers raise energy security concerns, not only for the national policymakers in individual countries, but also the entire Region.

The traditional concept of energy security addressed the relative availability, affordability and safety of fuels and energy services. The focus has changed significantly from the concerns of the 1960s and 1970s, when it was largely the perspective of OECD oil importers about ensuring a stable supply of cheap oil under threats of embargoes¹⁹ and price manipulations by exporters.²⁰ Later, with lessons learned from the realm of health care, the scope of energy security widened to include four criteria: availability, affordability, accessibility and acceptability. APEC, for example, in its 2007 report, developed energy security indicators for its economies using criteria such as net import dependency, diversification of supply and demand, environmental impact and oil security. The World Bank Group refers to three pillars of energy security: energy efficiency, diversification of supply and minimization of price volatility. Consumer advocates and users tend to view energy security as meaning reasonably priced energy services without any disruption. Major oil and gas producers focus on the stability of their access to new reserves, while utility companies emphasize the integrity of the electricity grid. Politicians dwell on protecting energy resources and infrastructure from terrorism and war and using energy to propel economic growth and employment. Scientists, engineers, and entrepreneurs characterize energy security as a function of strong energy research and development, innovation and technology transfer systems.

For many countries energy security also covers policy issues of providing universal energy access at an affordable price and sustainability of fiscal obligations emanating from such an objective. Import dependence is a major energy security challenge for about three billion people globally, where nations import more than 75 per cent of their oil and petroleum products; 95 per cent of transport energy comes from oil-based fuels, making it particularly vulnerable, with significant impacts on overall mobility and production systems, as well as on economic and social stability. There are physical security concerns, especially for third-country transit energy infrastructures. Many developing countries face

energy security stresses emanating from low resource endowments, a growing energy demand-supply gap, high energy intensity, and macroeconomic vulnerabilities with binding fiscal constraints. The level of uncertainty is much larger compared to dealing with supply disruptions or price manipulations.

Energy security also has a dynamic dimension; the perspective depends on the time frame over which it is being analysed. For example, if one is looking at a longer time frame, energy security is about stable and predictable prices, whereas affordability or continuous availability would be a prime concern over a short term. Similarly, there are fundamental differences between renewables and fossil fuels that would make security features of predominantly low-carbon systems different from those of the current system.

With such diversity in the concept of what constitutes energy security, it is necessary to distinguish concerns of countries at varying levels of economic development, and for those that extract, import, export and use a variety of energy sources and carriers. Energy security concerns also need to consider non-state actors, ranging from global production networks to small communities in remote regions, utilities and consumers, and other stakeholders having a variety of different goals and objectives. Climate change and social and environmental risks also figure prominently in today's energy security concerns. Finally, discussion of energy security has to include impacts arising from shocks (sudden change with short-term disruptions) and stresses (slowly unfolding but with longer-term impacts). This would inevitably mean that energy security must be reviewed not only for an individual country or a region, but also from the perspective of the nature of vulnerability (physical or economic disruption) for individual sector and geographic dimensions.

Available literature on energy security discussions covers many different indicators spanning multiple disciplines, and there are many assessment systems globally. IEA's Model of Short-Term Energy Security presents the energy security landscape of the 28 IEA member countries. The Global Energy Assessment evaluates energy challenges for individual countries. A set of recent studies covered future energy security based on long-term global energy forecasts.²¹ Given the specific concerns, the Pacific region has prepared energy security profiles using 38 indicators. Most of these studies are based on data and on ground conditions. The World Energy Council also prepares annual reports on energy issues, covering the triple challenge of finding solutions that simultaneously address the key aspects of energy security for economic growth, energy equity for social stability and environmental sustainability. Finally, at the international level, the Institute for 21st Century Energy and the United States Chamber of Commerce prepare an international energy security index to assess risks in global energy markets.

Several academic works are also worth noting. Benjamin Sovacool has proposed as many as 20 dimensions with over 320 indicators for measuring energy security in the Region²² based on stakeholder perceptions. There are also several other indices, sometimes referred to as complex indicators, constructed by adding the results from several quantitative indicators into a single value, where an index value represents a proxy for a general level of "energy insecurity". Such indicators need methods of aggregation or normalization that are not always transparent or objective.

It is difficult to generalize the concept of energy security for a region with so many different definitions²³ and indicators. It is possible to adopt generic approaches to energy security where physical or economic threats to energy security are common to most countries in a region. Some examples of generic energy security concerns include: minimizing the effects of energy systems on the climate; physical safety of energy systems, including from terrorist attacks or conflicts; free trade and secure transportation routes; resource depletion; cost escalation; and supply disruptions.

Table 2.2 Energy Security in the Region: Country Perspectives

Groups	Major vulnerability and risks	Security priorities
Developed economies: Japan, Republic of Korea, Australia, New Zealand	Supply disruptions, increasing import dependence, climate change impacts	Stockpiling, diversifying fuels and sources, attaining higher share of clean energy
Emerging economies with rising global energy share: India, China	Short-term supply disruptions in terms of physical supplies or prices, unsustainable energy supply-demand gaps, need for large investments in energy subsectors, resource constraints	Improving energy efficiency and demand management, diversifying fuels and sources of imports, reforming and creating markets
Major fossil fuel exporters: Australia, Russian Federation, Indonesia, Brunei Darussalam, Iran (Islamic Republic of), Kazakhstan	Stable energy demand, stable political economy, safety of transit routes	Protecting trade infrastructure and routes, continuing the flow of investments and technology, ensuring security of revenue streams, gaining access to new reserves
Middle-income countries with high import dependence	Energy price volatility, dependence on few sources	Diversifying import sources and fuels, investing in external reserves, maintaining flexibility in energy systems
Low-income countries with net import dependence	Low level of energy service infrastructure, low energy access, poor quality, frequent service interruptions	Establishing universal energy access, closing energy demand-supply gap from imports, securing capital and financing for investment in resource development and infrastructure
Small island countries	Climate impacts of global energy systems, stable prices especially for high speed diesel, energy access, affordability	Improving energy governance, data and information, ensuring stable flow of external aid, attaining global climate change agreement

Source: ESCAP

Another approach is to include concerns that are common to a particular group of countries, including all risks from natural, technological, economic and ecological complexities and uncertainties. No single set of metrics is suitable for assessing energy security for all purposes in all situations for these country groups. Table 2.2 outlines important factors contributing to energy insecurity of a nation, region or particular group of countries. Energy security in this framework is defined as low vulnerability of vital energy systems. The vulnerability of a system is the degree to which that system is unable to cope with selected adverse events. Such a framework allows review of security of vital energy systems from the perspectives of such criteria as criticality, likelihood of the event, and level and type of damage.

Regional connectivity enhances energy security through various channels, as described below.

- i. *Pooling diverse resources.* Some countries in the Region are highly dependent on fossil fuels, particularly coal, for power generation. There are opportunities for reducing fossil fuel use through regional connectivity, especially by importing hydropower from mountainous countries and from large-scale solar projects in desert regions. Bhutan, Kyrgyzstan, Lao People's Democratic Republic, Myanmar, Nepal, and Tajikistan all have large unexploited hydropower potential; the Thar desert in South Asia and the Gobi desert in China and Mongolia have considerable solar energy resources. Primary energy resource diversification will improve energy security, not only for one country but for the entire Region.

- ii. *Deepening natural gas usage.* Similarly, the Region includes large producers of natural gas with a huge potential for meeting demand for clean energy through pipelines or LNG. Energy-trading and connecting natural gas networks will provide the much-needed flexibility and options to deal with energy security concerns. A regional approach for introducing new technologies will also hasten the development of non-conventional gas resources, such as coal-bed methane and shale gas.
- iii. *Expanding feasibility of renewables.* Subregional electricity grids covering large geographic areas will be more suitable for accommodating larger shares of wind and solar power at the lowest cost. Renewables need to be harvested and transported over vast territories, in some cases beyond national borders. Additionally, renewable energy depends on variable wind, sun and exogenous conditions that are intermittent and more difficult to schedule than conventional fossil fuels. Given the limited and still developing electricity storage technology at utility scale, it is economical to integrate intermittent renewables into larger, flexible electricity systems. The fossil fuel-based generation can be backed down when renewables are available, and with an electricity grid system that covers large geographical areas, the available average renewable resources would be easier to schedule.
- iv. *Engaging in knowledge-sharing and technology transfers.* Regional energy connectivity will promote knowledge-sharing, technology transfer and innovation, by pooling expertise and research resources.
- v. *Seeing energy security as a regional public good.* More often energy security is considered vital for national security and therefore insufficient attention is given in national policymaking to the potential of cross-border energy collaboration. Instead, energy security needs to be treated as a global public good, as it is an integral part of human security²⁴ and various dimensions thereof.
- vi. *Understanding the economics of energy security.* Finally, regional cooperation reduces overall costs and thereby contributes to enhanced energy security, especially in countries where affordability and access are major energy insecurities.

6. Social and Environmental Drivers

Mitigation of climate change is a global challenge and ideally requires a global solution. However, often it is not possible to reach universal consensus and there are long gaps in actual implementation. In such situations, regions may be better placed to reach agreement due to common objectives and challenges, common historical and cultural backgrounds, geographical proximity and a smaller number of negotiating parties. This is especially true for environmental issues and climate change mitigation.

It is recognized that **the use of fossil fuel creates a range of severe problems in addition to climate change.** Many parts of India, China and most other countries, rich or poor, have serious problems with air quality in large cities. **The observed air pollution is calculated to contribute to 1.6 million deaths/year in China [0.7–2.2 million deaths/year at 95% confidence], roughly 17%**

of all deaths in China.²⁵ With rapid urbanization taking place in the Region in the next few decades, pollution and air quality remain a major concern for policymakers.

Climate change concerns also affect the perceptions of energy security and lead to pursuit of diversified fuel sources, as evidenced from the submissions of many countries to the 2015 Paris Conference. Natural gas is seen as the transition fuel and renewable energy resources, such as solar and wind, are seen as substitutes for fossil fuels. However, for many countries in the Region, it is difficult to reduce fossil fuel consumption unless the costs of fossil fuel alternatives become competitive. The long-term prospects for renewables are strong, and many are already competing with fossil fuels, but not all countries of the Region have a large potential to exploit such options. There is urgency to accelerate the transition to low-carbon growth and development but this goal cannot be fulfilled unless there is cooperation across the Region, not only for physical connectivity, but also around financing and technology.

The Region's geography can have an important positive impact on driving energy integration and connectivity. The long history of the Silk Road has created a large reservoir of cross-border social capital, comprising linked histories and cultures. Some of the remote regions have better linkages with communities in neighbouring countries than with the central government in their own country. Social and cultural similarities beyond border regions help create easy linkages and networks because it is often observed that when communities bond in recognized and comfortable groupings that are formed on the basis of trust, reciprocity and agreed norms of behaviour, there is less likelihood of failure. A large number of cross-border energy trade linkages can be scaled up, provided the negative impacts are mitigated and positive impacts are supported through a structure of incentives.

7. Knowledge-sharing, Innovation and Technology

Knowledge-sharing. The region exhibits a very wide range in human and institutional capabilities for meeting today's energy challenges. The Pacific region countries, for example, face challenges such as low economic growth coupled with rising inequality, small populations, limited energy and other resources, geographic dispersion, isolation from global markets, environmental and ecological fragility, high vulnerability to natural disasters and low capacity for managing the resulting risks. The region has weak data and information systems. Regional cooperation can assist these countries in many ways through sharing knowledge, coordinating technical aspects and pooling limited governance resources by institutionalizing regulatory functions for the entire region rather than duplicating regulatory institutions for individual countries. Possible areas of collaboration can include: technical and vocational training for small renewable energy systems; developing regional standards for new energy systems; installing as well as handling operations and maintenance; drafting templates for independent power producers and power purchasing agreements; and preparing rules for grid access, contracts and legal frameworks. For the petroleum sector there could be common fuel standards, information-sharing for global and regional prices and taxes, petroleum-contracting and advisory services. The region would also benefit from cooperation in energy planning and project analysis, frameworks for a sustainable energy agenda, and policymaking.

Innovation and technology. There are significant opportunities to move to cleaner energy systems; however, the capacity to adopt new technologies — often referred to as absorptive capacity — as well as to develop new technologies, is mainly located in a few countries. Adoption of new technology needs to be efficient, and often this requires economies of scale. Innovation and technology for new renewable energy systems requires research and development, the removal of financial barriers, and robust policies that support innovation and property rights. Often the cost of renewables depends on local conditions

and is based on the natural advantages of the region. For example, an abundant endowment will tend to reduce the local price of resources to the extent that they are not freely traded internationally. Trade restrictions may be due to high transport costs or variability of the resource price, which reduces the return to exports and thereby the opportunity cost of using the resource domestically. Local costs also depend on the capital endowment of the region. In this context, capital includes the accumulated stocks of physical capital and the financial capital needed to fund investment, the levels of human capital and skills, and the institutional and governance resources.



photo credit: retasite.wordpress.com

<https://retasite.wordpress.com/2012/03/22/overhead-transmission-lines-being-taken-down-in-the-uk/>



Chapter 3

Mapping the Existing Energy Connectivity

Throughout human history, different phases of globalization and development are tied to innovations in infrastructure connectivity. Recent studies on the history of technology find that Europe's integration began about a century earlier than the formal establishment of the European Community in 1951; infrastructure networks covering energy, transport and communications links have been the essence of European integration. Centuries ago, Asia, too, was well-connected, as the Silk Road created prosperous clusters of towns and trading posts. The Silk Route was a major channel for trade and the transfer of technology — it promoted knowledge-sharing on administrative practices such as standardized weights and measures, a system of numerical notation and identification, the labeling of commercial goods, and the opening of far-flung colonies.²⁶



The need for collaboration arises from the recognition that the costs of national self-reliance are usually excessive.

Earnest B. Haas²⁶

As late as 1800, Asia was one of the most open regions of the world and occupied an important position in the global economy not only in terms of population and production, but also productivity, trade, competitiveness and capital formation (Sakakibara and Yamakawa 2003)²⁷ and connectivity was a major contributing factor to Asia's prosperity. Today, as Asia is poised to retake its historic place in the world, it is time to rebuild regional connectivity and pursue actions for eliminating poverty, inequality and environmental risks. This was the exact dream of Michel Chevalier and other engineers of his time who believed, in July 1830, that creating peace treaties would not give Europe peace; it was the tangible networks, now known as infrastructure, that would forever change human conditions.²⁸

Defining Energy Connectivity

Most of the existing subregional programmes in the Region are at early stages of connectivity. Besides the limited cross-border power exchanges, there are a few cross-border energy projects with private sector participation. A list of projects, compiled from the subregional programmes, is placed at Appendix 1. Asian energy sectors remain largely national, with limited connectivity beyond borders. A number of subgroup leaders have agreed to move towards a completely integrated power sector programme; however, overall energy connectivity with efficient power markets remains quite distant as yet.

Experts distinguish between regional cooperation and regional integration as the underlying processes, for they are quite distinct. Regional cooperation remains contingent on usually voluntary, unanimous and continuous decisions of members. Entries and exits are relatively costless since there are no rigid organizations. As a result, collective efforts at the regional level are likely to be erratic, conditional and confined to pre-specified issues. Regional integration, on the other hand, is a formal process, based on treaties and legal instruments. In this report, these two terms are used interchangeably; however, this distinction needs to be kept in mind when setting up the institutions of integration.

It is clear that regional integration is a long process and has to be built up over three stages of energy network connectivity. So far, the Region is in early stages of energy connectivity and this is partly because the approach adopted is voluntary and informal. As can be seen from Table 3.1, a large number of the Region's economies have national power networks, whereas natural gas or other networks are limited to only a few economies. A number of cross-border exchanges occur, which are largely electricity interconnections along borders of many countries other than archipelagoes. Addition of cross-border projects leads to the "national plus" stage. The approach of subregional programmes is also bottom-up, building a portfolio of power projects in neighbouring countries. ASEAN is trying to shift to the next stage, which will have sector-based subregional programmes such as the ASEAN

Table 3.1 Defining Energy Connectivity and Integration

Characteristics	Energy Connectivity			Integration
	Largely National	National Plus	Subregional	Regional
Energy Exchanges	Border exchanges	Cross-border projects	Subregional programme	Seamless markets
Policy Framework	Not defined	Ad hoc	Sector-based	Well-defined integration policy
Policy Focus	National	National	Regional	Global competitiveness
Policy Process	Opportunistic	Negotiated	Treaty/ MoU	Integrated
Institutional Arrangements	Local	Transaction-based	Sector coordination	Formal legal framework
Regulation	Minimal	Contract-based	Sector institutions	Independent regulator
Transaction Costs	High	Very high	Decreasing	Low
Market Structure	National	National	Expanding	Competitive
Drivers	Trade	Projects	Sector leadership	Political leadership
Government Engagement	Low	Low	Medium	High, driving integration agenda
Supporting Infrastructure	Between two points	Project-dedicated links	Major corridors	High — full connectivity
Coordination Requirements	Low	Project-based	High	Use of markets
Energy Security	No significant impact	Diversification dividend	Improving energy security	Planning and coordinating energy security action plan
Power Exchange	India, Viet Nam	Lao People's Democratic Republic, Thailand	CASA 1000, GMS	Europe, WAPP
Natural Gas Pipeline Trade	India	China-Myanmar, Thailand-Myanmar	TUTAP	

CASA1000= Central Asia South Asia Electricity Transmission and Trade; GMS= Greater Mekong Subregion; TUTAP= Turkmenistan, Uzbekistan, Tajikistan, Afghanistan, Pakistan; WAPP= West African Power Pool

Source: Authors' adaptation

Power Grid and TransASEAN Gas Pipeline. Eventually, energy connectivity needs to be developed across the entire Region.

It is interesting that efficiency improvements and real economies of scale occur when power or natural gas is freely traded across different markets. The first three stages remain essentially bottom-up and opportunistic, dominated either by trade enhancement or private investment perspectives. As markets move up in the cooperation-integration process, demands for investments, capacity, technology and standardization increase. Since there is no single central energy organization in the Region, the process of gaining country-level approvals and accountability creates a major risk for all regional projects. Unless the entire project is implemented, overall benefits remain on paper and are not realized. Transaction costs for an individual project implemented under the first three stages remain quite high as it takes a lot of time and various approvals before a project can be implemented. The preparation for CASA 1000 project (Appendix 2), for example, began after a memorandum of understanding (MoU) was signed between countries in 2007, and even with bilateral support from the United States and technical and financial expertise and advice from multilateral organizations like the World Bank and others, the project was financed only in 2015, to be completed by 2020. Even when such projects are supported under subregional programmes, it takes a long time to reach financial closing, project agreements and statutory approvals.

There are several energy connectivity initiatives (Figure 3.1) in the Region, but most of these have yet to move up the integration ladder. The GMS is perhaps the most advanced of all subregional programmes in terms of harmonization of power policies and technical standards. In terms of subregional market creation, the Region is behind Africa or Central America, where power pools and market integration are at an advanced stage, though on a much smaller scale.

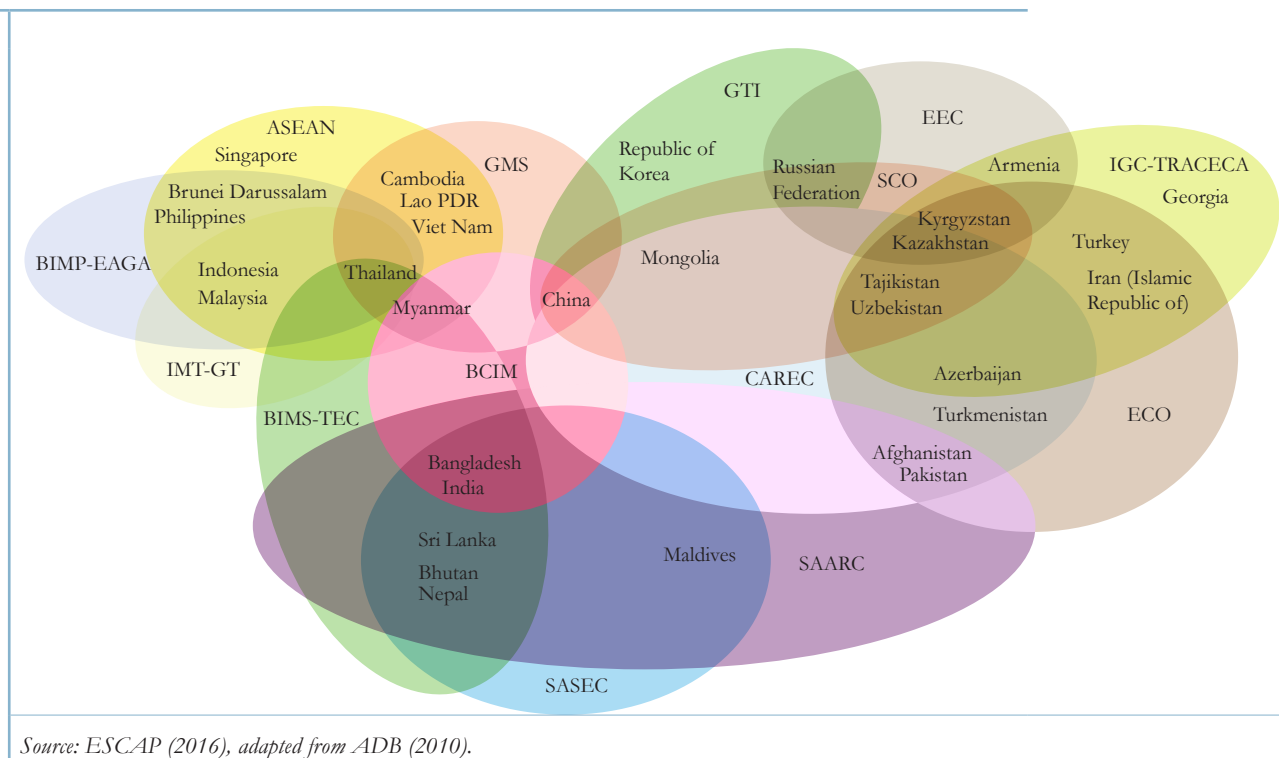
Benefits of Energy Connectivity and Integration

When challenges are addressed, benefits are realized, and so some of the discussion on benefits has appeared earlier, in the previous chapter.

Economies of scale and scope. The European Union and large countries like the United States, China, and India have integrated their power networks, which leads to augmenting national supplies and significant energy system cost savings due to economies of scale and scope. Major savings occur due to capacity cost savings for additional generation capacity through complementary demand profiling across countries, reserve margins, improved load factors, increased load mix, and coordinated maintenance schedules. Overall resource-pooling affords complementarities and comparative advantages for fuel sources used for power generation, and thus lowers overall costs. These factors lead to better regional efficiency through optimizing fuel mix. Similarly, natural gas networks help to diversify fuel sources and enhance energy security.

Sustainable energy for all. Regional energy connectivity also contributes to global goals of sustainable energy for all. Especially for countries that have low access rates, regional energy connectivity will increase energy supply and present multiple opportunities for connecting individuals, households and remote regions to modern energy, thus leading to job creation, advancing economic growth and development and helping to meet other sustainable development goals.

Figure 3.1 Energy Connectivity Initiatives



Expansion of sustainable energy solutions. There are often greater choices for renewables beyond country borders.²⁹ The single electricity market of Ireland has been able to introduce wind power as a major source of energy due to interconnection of the entire island of Ireland and Wales. Wind now accounts for 20-25 per cent of energy generation in Northern Ireland and 40 per cent in the Republic of Ireland, with the share being even higher at certain times. Similarly, a large number of countries in the Region have hydropower potential but lack financial resources as well as demand to justify such investments. Data on dependency of power sectors on fossil fuels show that it is possible to expand possibilities for improving fuel mix. The *Herschman-Herfindahl Index*,³⁰ used to assess fuel source dependency, indicates that for 60 per cent of countries for which such data exist, the dependency is high on few fuels, at values of more than 50 per cent. The world average is 25 per cent, compared to the Region average of 56 per cent. Energy integration will thus afford possibilities for many countries to diversify sources of power generation, including more sustainable solutions. The Region can use the large solar and wind potential that exists in many countries.

Social and environmental concerns. The Region has yet to create a large part of the energy infrastructure and so it is possible to mitigate social and environmental concerns and include these in the overall planning process. Most existing energy infrastructure is path-dependent and difficult to change because of technology lock-in effects. With most of the Region's energy infrastructure yet to be built, it can leapfrog to clean technologies using regional integration.

Trade and investment opportunities. The 2008 financial crisis recognized the role of infrastructure investments in stimulating growth and job creation. This is particularly true for distributed and renewable energy systems. The existing generation and network capacities are very constrained and a large potential exists for enhancing regional trade and investments. The Region has large savings and hence financial resources are not seen as major constraints. The biggest challenge is streamlining processes and removing barriers to energy trade, which would be a major source of economic growth.

Resource diversity. The disparity between energy demand and resource endowment means that there is significant potential to reduce overall energy costs in the Region and for individual countries, by exploring energy supply options beyond national borders. As Table 3.1 confirms, the Region is very diverse in terms of energy resource endowments and so it is possible to create bridges between resources and demand centres. The economic and political opening of two important countries in the Region — the Islamic Republic of Iran and Myanmar — is important as they are strategically located to be land bridges for energy connectivity, especially given their rich energy resource bases. Third- country access rights can enhance energy availability for the third country, and there are possibilities to increase government revenue through transit fees.

Dynamic competitiveness. As the experience of Europe and large countries indicates, regional integration helps to enhance efficiency of the economies currently facing large deficits. Improved energy availability attracts private investment and opens up new business opportunities. It is expected that this would lead to enhanced dynamic efficiency.

Learning and knowledge-sharing. The Asian global production network has shown that it is possible for economies to learn from each other and, through shared knowledge, create prosperity in the entire region. Asia has created successful clusters with virtuous cycles and has become the “factory of the world.” It is possible to replicate such success in the energy supply chain.

Energy security. Finally, one of the largest benefits of energy connectivity is enhanced energy security for the Region as a whole. By connecting resources with production and imports with regional supplies, it is possible to diversify overall sources of energy.

In conclusion, one cannot solve all energy challenges through regional integration, but smart Region-wide energy connectivity would go a long way towards improving the energy supply system and its environmental performance. It is possible for the Region to expand supplies, reduce overall cost of energy produced and consumed, lower environmental and social costs, and reduce energy insecurities if energy networks are connected. If there are so many benefits arising from energy connectivity, why is it that energy trade remains far below potential and large numbers of countries continue to face energy shortages while many countries are unable to use their resources? The next section will discuss measurement issues faced by policymakers in enhancing energy connectivity.

Measurement Issues and Examples

Measurement issues pose important challenges. It must be recognized that any transformation creates winners and losers. In a national economy, there are mechanisms available for compensation. A very simple example is the savings in transportation costs if regional resources are used, compared with a case in which required fuel is sourced from distant places. Typically, the difference between export and import prices is 10 to 12 per cent and it is estimated that in most developing countries national logistic costs account for 11-15 per cent of GDP (for larger countries such as China or India, the logistic cost is as high as 17 per cent). Such a wide margin leads to protracted negotiations in order to arrive at a fair and sustainable solution between the trading parties; it is difficult to measure all the costs and benefits and devise a method for sharing the difference. There are no simple rules and this is a major reason why the potential benefits of energy integration are not always realized.

There are many alternative ways to examine the economics of regional integration in any sector. The simplest way is to adopt a project-level approach to examining economic viability by integrating analysis of costs and benefits that occur beyond national boundaries. Though cost-benefit analysis is usually undertaken within the context of national boundaries, it is possible to consider the Region as a unit. Alternatively, a sector-based approach to integration that follows the same methodology would require making an exhaustive inventory of all candidate projects and then ranking these according to specific criteria so as to create a menu of possible projects that would fulfill regional integration objectives. Yet another simple way to measure benefits is to use optimization models where overall energy costs can be optimized for two cases: when the Region is treated as one country without national boundaries and when countries are treated separately. Differences between these two cases indicate the benefits of integration.

The GMS strategy was initially anchored in such an optimization exercise. Preparation of the strategy was based on MESSAGE (a Model of Energy Supply Systems Alternatives and their General Environmental Impacts). MESSAGE identifies the flow of energy from primary energy resources to useful energy demands that is feasible in both a mathematical and an engineering sense, and at the same time represents investment choices that lead to the lowest cost of all feasible energy supply mixes to meet a given energy demand. The model minimizes objective functions, or total discounted system costs, which include investment costs (both fixed and variable), operation and maintenance costs, fuel costs, and any user-defined costs such as environmental or social costs. The results from the various runs of the MESSAGE model indicated that regional cooperation would reduce overall energy costs. In fact, the stream of discounted costs under the GMS integrated scenario is more than 19 per cent lower than under the base scenario. Besides, integration reduces dependence on external sources of energy by 6 per cent and produces lower CO₂ emissions.

In the case of three transmission linkages, the South Asia region could benefit by annual savings of \$1.8 billion compared to a single one-time investment of \$700 million. If the streams of costs and benefits in these South Asia transmission lines projects are analysed, it is obvious that a large part of such savings is in terms of willingness to pay due to un-served energy. It is very difficult to capture the entire consumer surplus in such cases and so it may be difficult to monetize a large part of the savings. In part, these problems are due to the lack of reforms and absence of competitive energy markets in the Region.

According to another estimate, market integration in Europe brings annual savings of €12–14 billion, or €6.8/MWh of electricity consumed. When markets are competitive, consumers benefit from such integration and there are transparent processes to deal with issues of compensation. NERA, a consulting firm, carried out cost-benefit analysis of the single electric market for Ireland covering the period of 2005–2016. The estimate showed that the majority of net social benefit of integration goes to consumers.



Chapter 4

Lessons from Ongoing Initiatives

Subregional Initiatives for Energy Connectivity

Regional cooperation in energy has been evolving in Asia and the Pacific region mainly through five subregional clusters — South-East Asia, Central Asia, South Asia, North-East Asia and the Pacific. The small island nations in the Pacific have a very different perspective on energy connectivity; while physical infrastructure is unviable, software for managing energy security risks can be better organized through close cooperation, and the countries also benefit by sharing information related to distributed electricity generation, mini-grids, renewable energy and energy access. The Pacific Power Association, which is a partner agency of the Secretariat of Pacific Community, promotes cooperation among 25 electric utilities.³¹



So the energy market is increasingly a world market. ... regional events have an impact on global supply and demand.

Henk Kamp³¹

There are many examples of power export and a few examples of gas export in the Region that have been implemented by governments or under their direction following bilateral agreements. These have helped lower barriers but have not cleared the way to energy connectivity.

1. Existing Institutional Arrangements

At present, three institutional arrangements are used for bringing closer cooperation in the energy sector in the Region. The one that encompasses all countries is led by ESCAP, which is the principal regional body for coordination, policy review, policy dialogue and recommendations on economic, social and environmental issues, as well as implementation of internationally agreed development goals. ESCAP organized the first Asia-Pacific Energy Forum (APEF) in 2013; the next forum is scheduled for 2018. ESCAP also organizes regular senior official meetings and expert group meetings. The APEF also requested ESCAP, inter alia, to promote networking and information-sharing among member countries, and “to work closely with UN-Energy, the other regional commissions and other relevant international and multilateral organizations in implementing the present Declaration and Plan of Action on Regional Cooperation, and to continue to promote cooperation and partnerships in a synergistic manner with the various intergovernmental and non-governmental organizations, as well as private-sector and subregional organizations, funds and programmes that are playing an increasingly important role in enhancing energy security.”

The APEF Plan of Action also required ESCAP to improve energy statistics and to facilitate data- and information-sharing. Towards this end, the portal www.asiapacificenergy.org has recently been created, with support and funds from the Russian Federation. As more countries share data, information and energy statistics on a regular basis, the portal will potentially become a key platform for policymakers, investors, and project developers. Researchers will be able to analyse energy-related data and help identify alternatives for achieving a particular goal. ESCAP also publishes the annual *Regional Trends Report on Energy for Sustainable Development*.

Member countries have established APEC, ASEAN, SAARC, and the Pacific Islands Forum (PIF) using the second institutional arrangement. These organizations have their own secretariats for coordinating various cooperation-related activities. Recognizing the importance of the energy sector in economic and social development, they also have specialized energy centres. Member countries share the expenses of the secretariat and sectoral centres. Bilateral donors and international financial institutions also contribute by supporting specific studies and projects. It is likely that the Northeast Asia Peace and Cooperation Initiative (NAPCI), currently an effort led by the Republic of Korea, will develop into another initiative supported by regional member countries.

The member-led organizations have at their apex a head-of-government annual forum that is supported by energy ministers, as well as senior official meetings in the energy sector (with the exception of the PIF, which does not have a special group for energy). The energy centre collects and publishes energy statistics and research papers.

Asian Development Bank (ADB), for which regional cooperation and integration is a strategic priority, has created its own institutional arrangement. It is the secretariat and supports several subregional initiatives: GMS; Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA), Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT); CAREC; and South Asia Subregional Economic Cooperation (SASEC). The share of annual lending for regional cooperation projects is targeted to reach 30 per cent by 2020. GMS, established in 1992, was the first subregional group and a vast amount of knowledge has been developed since its founding. Box 4.1 provides a summary of energy sector activities in the GMS.

Since 2007, ADB has earmarked funds and managed contributions from the Government of Japan that provide grants for conducting studies requested by the subregional bodies. On 31 December 2014, its resources totaled \$62.8 million of which \$54.7 had been used.³² In 2005, the Government of the People's Republic of China (PRC) established the Regional Cooperation and Poverty Reduction Fund, which is also administered by ADB. It provided \$40 million and gives priority to technical assistance (TAs) for GMS and CAREC.

Regional cooperation is also supported in the Region by other international financial institutions, namely: the World Bank Group; European Bank for Reconstruction and Development; European Investment Bank; and Islamic Development Bank. The International Energy Agency (IEA) collects and disseminates energy statistics for Organisation for Economic Co-operation and Development (OECD) countries and non-OECD countries, including those in Asia. The quality, timeliness and coverage of energy statistics is more extensive for the OECD countries compared with the non-OECD countries. Further, overseas development agencies and institutions of OECD countries (particularly Japan) strongly support regional cooperation and market liberalization in the energy sector. Experts from multilateral and bilateral institutions have regularly participated in subregional meetings to share experiences and knowledge.

The decision-making process in all subregional fora is through dialogue and consensus; studies and projects have only been undertaken when all participating partners have been consulted and given their consent.

2. Lessons from Existing Institutional Arrangements

A third-party evaluation of the institutional arrangement has never been undertaken, and a comprehensive review would be beyond the scope of any single agency. The institutional arrangement is important for formulating strategies, defining goals, developing processes, implementing plans, measuring progress, making mid-course corrections, bringing together and managing resources, and building capacity.

The stated goal of regional cooperation is enhanced energy security and sustainable energy use. Experts and officials who have been participating in the ongoing initiatives do not appear to be confident that the existing institutions will achieve the goal. Some relevant comments are:

- i. *Knowledge-sharing is not practiced.* There are frequent meetings, conferences and workshops for sharing experience and analytical reports. The Internet also provides access to published reports related to energy connectivity. Over the years, ministers and officials from member countries have met regularly, which has helped them to understand the perspectives of others and build confidence. However, member countries do not readily disclose all energy-related data, so studies related to energy connectivity have to be carried out in partnership with the institutions that have the statistics. Obtaining reliable recent data has often been the most time-consuming and onerous part of analytical work, which makes it difficult to develop new and innovative policy options.
- ii. *Decision-making is delayed.* Extensive dialogue and consensus have ensured that studies and projects are undertaken only with the agreement of all partners. However, this has favoured implementation of bilateral infrastructure projects that required an agreement between two governments only. Although members appreciate the larger gains of a multilateral energy market, decisions requiring consensus among several partners keep getting deferred. Consensus-building has taken years in the case of major infrastructure projects, which has been frustrating for private sector project developers and institutional lenders. Clear policies, transparent processes and rigorous cost-benefit analyses are needed to shift to an objective decision-making process.

The Asia Development Bank (ADB) has supported regional

cooperation in the electricity sector in the Greater Mekong Subregion (GMS), which comprises six countries in South-East Asia, namely: Cambodia; the People's Republic of China (PRC, specifically Yunnan Province and Guangxi Zhuang Autonomous Region); Lao People's Democratic Republic (Lao People's Democratic Republic); Myanmar; Thailand; and Viet Nam. The group has a two-pronged approach for developing a regional electricity market, i.e. establishing policy and institutional frameworks and creating electricity grid interconnection infrastructure. The participating countries share land boundaries and have complementary energy resources, particularly the large hydropower potential in southern PRC provinces, Lao People's Democratic Republic and Myanmar that can provide clean electricity to cross-border electricity markets.

The Inter-Government Agreement on Power Trade (signed in 2002) established the Regional Power Trade Coordination Committee (RPTCC) to coordinate all activities of this group. It uses the work done by the subregional Electric Power Forum since 1995 and the Experts Group on Power Interconnection and Trade since 1998. With over 20 years of activities related to regional electricity trade, the RPTCC is the most visible institutional arrangement for promoting electricity trade in the Region. ADB is the secretariat of RPTCC.

Two working groups were established in 2011, one for coordinating performance standards and grid codes (WGPG), and another for regulatory issues (WGRI). More recently, an intergovernmental memorandum of understanding (IGM), signed by all participating countries in December 2013, enabled the creation of the Regional Power Coordination Centre (RPCC) as a legal entity for managing cross-border interconnections and trade in the GMS. Discussions are ongoing to select a suitable location for the RPCC.

International institutions have extended extensive support for developing regional electricity trade and the functioning of the RPTCC. Since 1992, ADB has provided technical assistance (TAs) and administered funds provided by donors that enabled studies related to strategy formulation, interconnections, generation planning, regulations, trading arrangements, environmental and social impacts, and project development. There were 14 regional TAs for a total of \$21.8 million, 10 TAs for a total of \$5.7 million provided to Lao People's Democratic Republic, and a TA for \$0.7 million provided to Cambodia.

Box 4.1 Summary of Activities in GMS

- iii. *Energy security is not ensured.* There is an apprehension that energy connectivity would lower energy security for a country, except when specific projects are implemented in neighbouring countries to import electricity or gas. Governments have considered energy to be of strategic interest and are inclined to hold back their plans for developing resources to meet future energy demand. Furthermore, most countries import oil, so governments fear that disclosing consumption data could weaken their negotiating positions. This view is gradually changing, as the reality is quite different, particularly for oil. Timely availability of demand data enables developers and investors to bring new energy supplies on stream, which helps to overcome price volatility. In addition, the Region leads energy consumption and its energy supply-demand gap influences the global energy prices — particularly oil, coal and gas, which are extensively traded. Therefore, wide and timely sharing of energy sector information would have a positive impact on energy security.
- iv. *Asia has too much diversity.* Countries in the Region have varied industry structures and very large differences in levels of energy consumption. Officials know that harmonization of rules and standards will be necessary but there is no institutional mechanism to coordinate the actions to be taken by member countries. At the same time, the Region is well versed in the management of interconnection of electricity grids, which routinely happens within China and India, as these countries have interconnected provincial-level grids and these are further interconnected to improve efficiency and supply reliability.
- v. *Project preparation is insufficient.* Preparation of bankable proposals for regional interconnection and export-linked electricity generation projects is given low priority, lacks resources and remains uncoordinated. There are several conceptual proposals for regional energy connectivity that indicate considerable benefits but follow-up techno-economic feasibility studies have not been carried out to establish their viability. Generally, the difficulty has been a failure to treat the linked components as a single project and to carry out comprehensive analysis.

3. Regional Interconnection Projects and Energy Trading Arrangements

Some high profile regional interconnection projects include the Nam Theun 2 hydropower project in Lao People's Democratic Republic that is exporting electricity to Thailand, the Central Asia South Asia Electricity Transmission and Trade Project (CASA-1000) that will export available excess electricity from hydropower projects in the Kyrgyz Republic and Tajikistan to Afghanistan and Pakistan, and the Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipeline project being developed to meet the large demand for natural gas in Pakistan and India.

The ongoing projects focus primarily on electricity and gas pipelines. However, countries also need oil for transport and increasingly depend on internationally traded oil. The price is generally agreed bilaterally, although Platts has recently introduced Free-on-Board (FOB) Straits, which provides a market-determined price of refined oil products from commercial storages in Singapore and Malaysia. There are plans to implement larger commercial storage and another oil hub in the Republic of Korea.³³

Natural gas trade in Asia is dominated by long-term supply contracts for LNG with oil price indexation. Gas has been purchased mostly by state-owned enterprises following government policies. Gas prices in Europe and the United States peaked in 2008 but prices have increased in Asia following the economic recovery and the nuclear plant accident in Japan in 2011. Concerns have been raised about the high gas prices in Asia and efforts are being made to combine the purchasing power of major consumers to negotiate better terms from the suppliers.³⁴

Private sector participation in energy sector discussions has been conspicuously limited, with two exceptions. The Japan Renewable Energy Foundation, established by Masayoshi Son, Chairman and CEO of Softbank in Japan, is supporting the Gobitec and Asian Super Grid proposals. In 2014, the World Economic Forum, in collaboration with the Boston Consulting Group, published a report for Africa that includes challenges and best practices for implementing cross-border infrastructure projects.³⁵ While consultation with the private sector has been minimal, it has developed and implemented several projects in South-East Asia for bilateral electricity trade.

International Experience with Energy Connectivity

The electricity business changed in the United States and Europe at about the same time. Orders issued by the Federal Electricity Regulatory Commission (FERC) in 1996 and 2000 led to unbundling of state-level utilities in the United States and encouraged inter-state competitive wholesale electricity markets. Similarly, a European Union (EU) directive issued in 1996 launched a single European electricity market.

The private sector entities that owned vertically integrated state-level utilities in the United States were initially apprehensive about restructuring because of fear that assets would be stranded. Therefore, the FERC order provided means for recovery of the stranded costs. In Europe, the electricity supply industry had not been unbundled in all EU member countries so the directive allowed flexibility but required utilities to disclose the rules and not to discriminate.

The experience with competitive wholesale electricity markets across borders has generally been positive in mature economies where electricity consumption has flattened out or is declining. The industry is better equipped to face new challenges, it remained financially sound while fuel prices peaked in 2008 and it is also shifting to power generation using renewable resources to lower the carbon footprint. The business model is defined by non-discriminatory open access to networks, competition in wholesale and retail supply, and addition of new assets on the basis of market-determined prices. The same approach is being used in the wholesale gas markets that are supplied using extensive pipeline networks. Other regions and developing countries now recognize the success of this business model and several regional initiatives are being implemented. A brief description of some regional gas and electricity markets is included in Appendix 3 and an overview is provided in this chapter.

1. Henry Hub in the United States

The United States is the largest gas-producing and gas-consuming country in the world. Its gas consumption in 2014 was 756 BCM, while that of the world was 3,505 BCM. The gas network in the United States is extensive and connects to neighbouring Canada and Mexico. The wholesale gas market was completely deregulated in 1993 and transactions are done at over 20 major gas hubs, with the highest volumes going through the Henry Hub (51 million cubic metres per day). The Henry Hub day-ahead price has become the benchmark for transactions at other hubs. Gas derivative markets have developed that require settlement at the Henry Hub. The monthly average spot price during the past 18 years has remained between \$92 and \$106 per thousand cubic metres.

While the domestic gas market has been opened, the United States government controls the export of LNG. At present, five LNG export terminals are under implementation and another three have been approved but construction has yet to start.

2. Britain's National Balancing Point

Britain consumed 64 BCM of gas in 2014. The country imports gas through several pipelines connected to continental Europe and also has LNG terminals. National Grid, a private sector company, owns and manages the wholesale gas transportation system.

The National Balancing Point — i.e. the gas transmission system — is the virtual gas market, where all market participants are required to balance the daily physical and traded positions. If a buyer withdraws more gas than that buyer bought during the day, National Grid imposes “cash-out” charges based on cost incurred to balance the system. While buyers and sellers determine the gas price, the regulator determines the tariff to be paid to National Grid for managing the transmission system. Based on the number of market participants and the large number of daily transactions, the National Balancing Point is considered more competitive than other gas markets of Europe.

3. The Netherlands' Title Transfer Facility

The Netherlands is a gas-exporting country; in 2014 it produced 66.3 BCM and consumed only 38.4 BCM. The gas transportation system is connected to Belgium, Britain, Germany and Norway, which makes the Netherlands a major international hub. The Title Transfer facility is a virtual marketplace, established in 2004, where participants trade the gas that has already entered the transmission system. Gasunie, a wholly state-owned enterprise, owns the gas transmission system, and its subsidiary is the independent system operator. ICE Endex, a partnership of International Exchange and Gasunie, operates the spot and futures markets (up to five years ahead). The daily gas price has been about \$220 per thousand cubic metres and futures for 2018 are available for \$240 per thousand cubic metres.

4. Southern African Power Pool

The Southern African Power Pool (SAPP) was formally established in 1995 for coordinating the power systems of twelve member countries of the Southern African Development Community. National power utilities, transmission companies and independent power producers are members of SAPP, adding up to 16 market participants. SAPP is a non-profit organization under the Southern African Development Community and has its own governance structure.

There are 24 cross-border transmission lines in the region and about 7 per cent of the total power produced flows over the interconnections. Both day-ahead and post-day-ahead markets are working, although most of the trade is on a bilateral basis. There is a large potential for competitive trade but it is limited by transmission constraints.

The main trader in the region is a 2,075 MW hydropower project in Mozambique that exports power through a high-voltage direct current link to South Africa. Only two countries have unbundled the power sector and private sector participation has been minimal in the region. Development of regional trade is expected to create the environment for implementing the Grand Inga hydropower project, considered to be the world's largest, with an estimated capacity of 40,000 MW. Recently, the World Bank provided support for a Project Acceleration Team that will prepare priority regional projects.

5. Central American Power Market

Six contiguous countries in Central America have created the Central American Power Market as an additional electricity market. A single 220 kV transmission line system is strung across the six countries,

allowing cross-border electricity flows. The region is also connected to Mexico in the north and a link to Columbia is being implemented in the south. Three regional agencies have been created; one is for operating the electricity market, the second is the regional regulator and the third is the regional transmission company.

Two countries have vertically integrated national utilities and the other four countries have unbundled the sector. The full potential of regional trade has not been realized because of the lack of long-term contracts and an agreeable wheeling tariff. At present, 5 per cent of the electricity generated is traded in the region.

6. European Energy Union

In 2014, the power generation in 35 countries of Europe was 3,310 TWh and the cross-border electricity flow was 444 TWh (13.8% of generation). The national transmission system operators are members of the European Network of Transmission System Operators for Electricity (ENTSOE) that coordinates the integration of the transmission systems.

EU-28 currently has seven interconnected electricity markets and 24 power exchanges operated by the private sector. In 2014, the monthly average day-ahead baseload electricity price was different in various markets; the highest (€57/MWh to €61/MWh) was in Britain after the increase in climate change levy, and the lowest (€13/MWh to €31/MWh) was in Northern Europe, mainly because of the large share of hydropower.

In February 2015, the European Commission announced plans for a fundamental transformation of Europe's energy system that will move to a single market across the whole of Europe. The proposed change will better meet the requirements of Europe's ambitious climate policy and bring improvements for consumers and businesses.

7. Pennsylvania-New Jersey-Maryland Interconnection (PJM)

The Pennsylvania-New Jersey-Maryland Interconnection (PJM) covers 14 states in the United States. It is the largest of the ten electricity regions in the country. It runs the competitive electricity market for five related products, including a capacity market based on a reliability pricing model for ensuring adequate generation capacity.

The average wholesale electricity price in 2014 was \$71.62/MWh. According to PJM estimates, the annual savings from the integration of electricity markets amounts to \$2.8 billion to \$3.1 billion.

Lessons from International Experience

Many lessons can be drawn from detailed analysis of the regional and international energy markets. When the Asia-Pacific Region decides to create subregional markets, it will be useful to send study teams and review the institutions, governance structures, disclosure requirements, products that are traded, methods used to determine price, practices of market supervision and outcomes of the markets. The following are some key lessons from international energy markets:

- i. Policymakers rely on improved energy trade and competitive energy markets for addressing challenges — e.g. addressing climate change and extending energy to all.
- ii. It is possible to accommodate different structures of the energy sector in member countries while designing instruments for regional energy trade; however, eventually unbundling of transmission systems will be essential.
- iii. Bilateral energy trade can be developed based on contracts but wholesale competitive markets are better for taking full advantage of the diversity among member countries.
- iv. Large investments are needed to capture the benefits of energy trade, which require private sector investment.
- v. Robust institutions have to be created for promoting and managing regional energy trade.
- vi. Markets are possible for regions with relatively low energy consumption and also for very large energy-consuming regions.
- vii. Although wholesale markets send price signals, that is not a sufficient condition for attracting private sector investments; project developers and lenders make their own projections for which all energy-related data has to be publicly available.
- viii. Markets require adjustments from time to time for maintaining a balance between the interests of investors and energy consumers.





Chapter 5

Towards Energy Connectivity in the Asia-Pacific Region

The UN-ESCAP members combine both the largest producers and the largest consumers of energy. And although the Asia-Pacific Region is connected to the global economy and is the largest trading area of the world, accounting for 37 per cent of world trade, energy trade remains much below its overall potential. This chapter articulates the vision for delivering the Ministerial mandate given to ESCAP at the first Asia Pacific Energy Forum in 2013 and outlines actions needed to realize energy connectivity for Asia and the Pacific Region.³⁶

As we have seen in the last chapter, there are numerous ongoing initiatives for energy connectivity in the Region — GMS, ASEAN, North-East Asia, SAARC, CASA-1000, CAREC, APEC, BIMSTEC, CROP, ECO, SCO, EEC, and SASEC — all of which look at energy connectivity from a limited subregional perspective. There is some duplication of effort and the subregions are developing their own parameters, making Pan-Asia integration that much more difficult in the future. Vast amounts of human and financial resources are being used but achieving the full potential for energy cooperation in this vast region still remains a distant goal. With directions and guidance from the APEF, ESCAP is now well positioned to lead and fast-track energy connectivity for the entire Region.



We can no longer afford to think and work in silos.

Ban Ki-Moon³⁶

Asia and the Pacific account for a major share of the world's incremental energy use; therefore, overall responsibility for the quality of energy use and its impacts on the global sustainable development agenda will be largely determined by policy actions taken by the Region.

Benefits of Energy Connectivity

It will be useful to reiterate the overall benefits of energy connectivity before proposing the actions needed to achieve it. Regional connectivity enhances collective efficiency. Regional connectivity allows countries to achieve dynamic competitiveness collectively by enhancing efficiency through economies of scale and scope. Better energy outcomes lead to a better investment climate, higher economic growth and additional employment opportunities. Regional energy connectivity is thus a global public good.

photo credit: Potpot / www.traveltrilogy.com

<http://www.traveltrilogy.com/2014/03/bangui-windmills.html>

The major goals for regional energy connectivity discussed earlier are summarized below:

- i. Use the Region's resource diversity to enhance national energy supply to support energy access goals and inclusive development agenda;
- ii. Connect to larger energy networks to reduce the overall cost of energy, reduce environmental burden and benefit from economies of scale and scope;
- iii. Pool the Region's renewable energy resources and increase the share of renewables, either locally or through greater connectivity;
- iv. Optimize the fuel mix based on regional resource base and pool inherent risks;
- v. Improve overall energy security and reduce dependence on a single source or fuel;
- vi. Build physical energy networks to underpin regional growth and employment creation;
- vii. Share knowledge and transfer of technology; and
- viii. Exercise leadership in global decision-making relating to energy under the Sustainable Development Agenda.

Regional energy connectivity will create incentive structures and institutions to deliver cost-effective energy for the entire Region. However, as we have seen, the task is not an easy one. Asia was able to transform itself and reduce poverty by building global production networks and creating efficient supply chains for the entire world by relying on markets and supportive policy regimes. Energy networks, by their inherent nature, are not amenable to market forces and hence there is a clear role for non-market players and governments to work together to remove barriers to greater connectivity. ESCAP is in a unique position to lead such a transformation to a fully energized Asia and the Pacific Region.

Towards Asian Energy Connectivity

Energy markets do not connect by themselves; in the next few decades, actions will be needed to build physical energy networks, institutional connectivity and, most importantly, trust between nations to meet the Region's two most important challenges — overcoming poverty and mitigating climate change. Secure, sustainable and stable energy at affordable prices will be key to meeting these challenges. In today's interdependent world, no single country can address the energy challenges using its own resources. World leaders are now seeking closer cooperation for achieving development goals. On 25 September 2015, world leaders formally adopted the new framework, "Transforming Our World: The 2030 Agenda for Sustainable Development" and the Secretary General launched the "renewed global partnership" and reiterated that "*The 2030 Agenda compels us to look beyond national boundaries and short-term interests and act in solidarity for the long term. We can no longer afford to think and work in silos.*"

Governments, policymakers and experts must work together, with the guidance of ESCAP and in partnership with the private sector, to provide sustainable energy for all by 2050 through connecting Asian energy networks and building institutions of integration. The past few decades have seen

significant efforts towards energy connectivity fragmented across various subregional initiatives. These initiatives started the process of building a strong foundation. Now is the time to expand and build on these initiatives to create a fully networked Region. It is time to build energy connectivity for an interdependent Asia and the Pacific — prosperous and connected — thus ending Asian economic dependence on a single source or a single fuel.

By 2050, we envision a connected, fully energized Asia and the Pacific Region, where the following will be true:

- i. Energy interdependence fosters harmonious relations between members and thereby yields a peace dividend that improves quality of lives, supports wealth creation and protects the environment for future generations;
- ii. Expanded supply and robust networks enable universal energy access and delivery of crucial social services including education, health, communication and leisure;
- iii. Reliable energy supply supports the member economies in creating employment opportunities and robust economic growth;
- iv. Large regional renewable energy resources — hydropower, wind, solar and tidal power —are unlocked;
- v. Technologies that limit ecologically damaging footprints are mainstreamed — e.g. efficient fossil fuel production and conversion;
- vi. Innovations in transportation and other energy applications help de-carbonize economies;
- vii. Additional resources sourced from the private sector for implementing cross-border infrastructure under public-private partnerships (PPPs) help create robust and competitive energy markets;
- viii. improved regional energy governance strengthens transparency and streamlines approvals of regional projects including transnational natural gas pipelines, power grids and secured energy transportation routes;
- ix. Harmonized energy policies, regulations and standards lower overall risks;
- x. A conducive environment is created, where innovations and local adaptations allow countries to leapfrog to cleaner and sustainable energy sources; and
- xi. Thought leadership and knowledge-pooling underpin sustainable development of the energy sector and thus the entire Region.

A number of models and trends indicate that the 21st century belongs to Asia and it is time to consolidate resources to build Pan-Asian energy networks. Now is the time to move away from processes in which subregional projects take years to move from ideas to drawing boards to the ground. It is now time to save millions spent on preparation of projects and lengthy negotiations to approve a single project. It is now time to build new institutions for this century, where ideas and innovations can be implemented before it is too late. It is now time to divert financial and human resources to build the physical energy assets that are so clearly needed to light up a home or create jobs.

Regional Action Plan

The process of achieving Region-wide energy connectivity has already started, as ESCAP has a natural advantage in bringing the various groups of stakeholders together and driving the energy connectivity agenda for this vast region. The Ministerial Declaration of the Asia Pacific Energy Forum 2013 recognized that enhanced energy trade is a powerful catalyst for strengthening intraregional cooperation in energy security and sustainable use of energy. Greater connectivity among energy producers, transit and consuming countries would lead to increased energy access across the Region and facilitate economic development. The Ministerial Declaration has outlined an ambitious Action Plan covering both physical networks and institutional aspects for regional economic integration. In this section, five action points are suggested to achieve the long-term goal of regional energy integration for the Region.

Action 1: Remove barriers to energy trade. Though governments realize many benefits of greater energy connectivity, a number of countries have restrictions on exports and imports of power and natural gas. In many countries there are explicit restrictions, whereas in others, taxes and subsidies distort incentives for exchanges. The first action in regional energy connectivity, therefore, has to address the issue of explicit or implicit trade restrictions.

Action 2: Improve the investment climate. The market structures for energy in the Region remain quite diverse. A number of countries have central, government-owned utilities for the energy sector, but there are also liberalized energy markets in the region. Connecting such a diverse range of networks poses major risks. There is a need to move to reforms by which efficient energy markets are created. Regional energy connectivity can bring new investments, efficiency improvements and new technologies. However, realizing these dividends requires governments to carry out sector liberalization, modernize monopolistic utilities and rationalize the role of government in creating competitive market structures. Though the Region has adequate savings at macro level, collective actions to promote private investment in secure energy connectivity have yet to be taken.

Action 3: Create an Asia-Pacific Energy Charter. There is more than enough political support for regional energy connectivity. At various fora, technical experts have quantified the benefits of greater energy connectivity. At subregional levels, too, there have been many declarations of intentions to promote energy connectivity. It is proposed that these various intentions and declarations be formalized in the shape of an Asia-Pacific Energy Charter, so as to convey the long-term commitment of member governments and provide confidence for the private sector and institutional investors that supporting policies and instruments for greater energy connectivity will be in place in a time-bound fashion.

Action 4: Establish institutions of regional energy integration. We need to recognize that integrated markets require integrated institutions. A number of institutional mechanisms to promote greater cooperation across the Region have been set up, but most of these are limited by their mandates for the subregional programmes or initiatives and add little to the vision of regional energy integration for the entire Region. Institutional design will be fundamental to developing and sustaining competitive energy markets for the Region in the long run. Details of proposed institutional arrangements are spelled out in the next chapter, but in summary, it is proposed to set up two institutions, the Asia Pacific-Energy Centre and the Asia-Pacific Energy Agency, with mandates to implement the vision of regional energy connectivity.

Action 5: Engage in knowledge-sharing and capacity-building. The global energy sector is undergoing multiple transitions³⁷ and human and institutional capacities need to be built to benefit successfully from these changes. Country-level information systems need to be enhanced to share

knowledge and learning. There is also a large potential for developing common standards and documentation for promoting private sector investments.

Suggested Work Programme for ESCAP

Besides generating political and technical ownership of energy connectivity in the Region through advocacy and leadership, ESCAP will need to support an action plan with specific actions as identified below:

- i. ESCAP needs to initiate research and collate information on the existing trade regimes for energy products and services and identify explicit and implicit barriers to trade as a first step. Depending on the findings, an action plan can be prepared to free up the trade of energy services through networks for both power and natural gas.
- ii. To help the Region in planning full energy connectivity, ESCAP will need to establish a Preparatory Committee of energy experts that can initially guide the process of setting up institutions of integration. The committee should include regional energy experts (in their own capacities) and others knowledgeable about the diverse challenges of regional cooperation in the energy sector. Such a multi-disciplinary group will help to build momentum for pushing the agenda of regional energy connectivity for the entire Region.
- iii. ESCAP will need to support initial preparatory work to draft the Asia-Pacific Energy Charter. A number of guiding principles that can be included in the draft Asia-Pacific Energy Charter have already been identified in the Ministerial Declaration and the Action Plan therein.
- iv. ESCAP will need to initiate action for setting up an Asia-Pacific Energy Agency (APEA), a special purpose public vehicle (SPPV) to prepare projects that will boost regional energy connectivity. This work will include preparation of a draft agreement for membership in the SPPV, resource mobilization for the initial period, and design and outline of the organization.

The next chapter proposes detailed proposals to set up institutions of integration in the energy sector to support the vision of energy connectivity for the Region. Investments will follow, if the underlying environment promotes energy integration.

Institutions for Promoting Energy Connectivity

Approach to Energy Connectivity – Public Private Partnership

Several estimates are available regarding the investment needed in the energy sector.³⁸ The IEA has estimated that the required investment in Asia in the energy supply (including fuel production) and to improve energy efficiency under the New Policies Scenario will add up to about \$15 trillion (2012).³⁹

In another study, ADB has estimated that the investment needed in the energy sector (excluding fuel production) in the developing countries of Asia from 2010 to 2020 will be \$4 trillion (2008). The study also estimated that the share of investment in regional projects would be about 4 per cent of the national investment, which is comparable to the case in Europe.⁴⁰ Using these estimates, about \$20 billion will be needed annually for energy connectivity infrastructure in Asia and the Pacific region. At the 2015 Paris Climate Conference, member countries committed to lower emissions, which will require more power generation using renewable

energy, reduction in losses and use of new technologies to improve efficiency. The required annual investment will be higher as energy planning shifts towards cleaner energy.

“By reducing uncertainty and the costs of making and enforcing agreements, international institutions help states achieve collective gains.

Robert O Keohane³⁸

The governments in the Region have gradually moved away from providing budget support for mainstream energy infrastructure projects, and now limit such support to extending energy access and promoting renewable energy. The Region has a high savings rate in households and private sector corporations so availability of funds would not be a serious issue provided reasonable returns on investment are available for projects. The PPP model will be useful for shifting from public to private sector investment, particularly for the networks that are run efficiently as monopolies. The private sector is going to be a major player in energy connectivity even though it is a public good. PPP is broadly defined as a “long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance”.⁴¹

Application of PPPs for regional energy infrastructure will need to deal with some specific issues:

- i. *Long-term contracts.* Unlike other industrial assets, the useful life of power grid interconnections and natural gas pipelines is very long; the early installations have completed 40 to 50 years of service and continue to operate with reasonable reliability. The technology, engineering standards and operation practices have significantly improved so new network infrastructure can be designed to have over 50 years of life with minimal maintenance costs. On the other hand, the tenure for commercial loans to such infrastructure projects in Asia is often less than 15 years, even in emerging economies with reasonably strong financial markets. Furthermore, the economic variables undergo considerable change during the period; interest rates and foreign exchange rates change so the economic growth rate and the linked energy demand could be different five years after the estimates that were used for project justification. On the other hand, investors and project developers face less of an issue regarding technology obsolescence — electricity or its transmission to demand centres is not likely to be replaced by another technology. Investments in properly designed and well managed energy connectivity assets will provide stable long-term returns, though renegotiation of contract terms may become necessary for adjusting to the changing macroeconomic conditions.
- ii. *Multiple government and private entities.* The simplest cross-border infrastructure will require agreements between at least two governments. If the routing of the power transmission line or gas pipeline needs to traverse through a third country, another government will be involved. Furthermore, open or third-party access to network infrastructure helps lower the capital costs, which then requires agreement between multiple sellers and buyers. The transaction cost and time can be made manageable by using a transparent and objective process for identifying, preparing and selecting developers for energy connectivity infrastructure projects using the PPP model. In addition, prior consultation with a wide range of stakeholders will build support for implementation and operation of PPP projects.
- iii. *Sustainable use of energy and energy access.* The emphasis is going to be on sustainability while developing regional energy connectivity so power generation is going to be biased towards the use of renewable resources that have low emissions — namely hydropower, solar and wind. When power grids in different time zones are interconnected, the difference in peak demand periods will reduce the reserve margin requirement and obviate some peaking power plants. Natural gas, whether in bottles or piped to households, is the clean cooking fuel of choice so new networks will be needed to provide access to all. Therefore, the PPP models for energy connectivity projects will need to accommodate such issues as viability gap, intermittency of supply and small markets.
- iv. *Bankable projects.* No matter how desirable a regional infrastructure project is from the viewpoint of providing public service, it has to be bankable so the developers can raise capital. It should be able to attract both equity and debt. Equity holders have a higher appetite for risks since the expected rewards are also high. However, a lender's return is linked to interest rate so the project cash flow has to be adequate to cover debt service obligations during the loan tenure. When structuring a PPP regional project, the government — or governments — will need to balance the risks and rewards; the payment to the private sector party will have to be linked to agreed performance standards and risk must be assumed over the life of the asset. Furthermore, transnational projects attract close scrutiny from international civil society and therefore have to be built according to high standards; this lowers the reputation risk for international financial institutions that support such projects.

Charter and Institutions of Regional Energy Integration

Based on the rich experience of the functioning subregional initiatives, steps have to be taken so member countries gain the maximum benefit from energy connectivity. Recommendations for bringing all member countries under a charter and establishing new regional institutions were mentioned in Chapter VI, and further elaboration is included here.

1. Asia-Pacific Energy Charter

The objective of the Asia-Pacific Energy Charter will be to assure the private sector, institutional investors and other stakeholders that members share the view that energy connectivity is a suitable instrument for improving energy security and sustainable use of energy. The collective approach will reflect the fact that the Region already consumes close to half the world's primary energy and will be growing rapidly for several more decades. Further, the new Asia-Pacific Energy Charter will demonstrate the Region's willingness to assume the responsibilities of the leading energy-consuming region and strengthen its position in future international discussions.

The proposed Asia-Pacific Energy Charter will be a non-binding agreement on the vision, objectives, principles, policies, institutional arrangements, and milestone and target dates. The Charter should emphasize that sovereign governments will retain control over national assets and encourage energy trade for promoting energy access and sustainable use. A key to the success of regional integration would be in defining the basis for fairness — i.e. what will be considered fair and equitable sharing of costs and benefits of energy trade. All countries in Asia and the Pacific would need to sign the charter. It is expected that international financial institutions and bilateral donors would see the charter as a tangible step and consider supporting the preparation of a suitable draft charter, consultations, negotiations and resolution of issues needed to build consensus among the member countries.

The Ministerial Declaration of APEF 2013 encompasses both the national and regional dimensions of energy security, as well as sustainable use of energy and access for all. As a starting point, the Asia-Pacific Energy Charter needs to include the shared beliefs mentioned in the Ministerial Declaration that have regional energy connectivity implications, as listed below:⁴²

- i. Reference to UNESCAP's resolutions of 2011 and 2013 for promoting intercountry energy cooperation.
- ii. Para 1. Energy security is a key development challenge for all countries in Asia and the Pacific, including the least developed countries, landlocked developing countries and small island developing states.
- iii. Para 5. The Region has the largest producers and consumers of energy and the potential for intraregional energy trade is scarcely exploited.
- iv. Para 8. Resolve to have a greater regional voice in international forum and participate actively in regional and global decision-making process.
- v. Para 12. Make every effort to improve transparency, predictability and stability of the energy market in the Region.

- vi. Para 14. Interconnect existing power grids to boost trade in electricity, eradicate poverty, increase access to electricity and facilitate economic growth.
- vii. Para 15. Establish regional and subregional energy or electricity bourse and markets for costs to be reasonable for producers and consumers.
- viii. Para 16. Develop and widen the use of low-emission and cleaner coal and oil technologies because use of fossil fuels is rising for supporting rapidly growing economies in the region.
- ix. Para 19. Increase the share of renewable energy resources in the regional primary energy mix.
- x. Para 27. Enhanced energy trade is a powerful catalyst for strengthening intraregional cooperation in energy security and sustainable use for all participants, including energy-producing, energy-transiting and energy-consuming countries.
- xi. Para 28. Attach great importance to establishing a conducive environment for investment in production, transit and delivery infrastructure, and to trade facilitation policies in primary energy and electricity.
- xii. Para 29. There is a large potential and need for energy connectivity and for large markets through cross-border infrastructure and energy trade, including oil and gas pipelines and electricity grids; such regional and subregional cooperation is crucial for ensuring reliable, efficient and safe transportation of energy resources, thus increasing energy security.
- xiii. Para 32. Further improve the investment climate in Asia and the Pacific using public-private partnerships for implementation of cross-border energy infrastructure.
- xiv. Para 35. Invite all regional and subregional organizations to work collectively on addressing the challenges in the energy sector.
- xv. Para 38. Commit to active technology cooperation related to production, transportation, processing and consuming energy, including fossil fuels, renewable energy and energy efficiency.

Further, with a view to accelerating energy connectivity, the member countries would need to agree to:

- i. Cooperate and participate in establishing the Asia-Pacific Energy Centre, which builds on the available expertise in various research institutions and subregional organizations and connects with the IEA for smooth flow of information and analytical expertise. The Asia-Pacific Energy Centre will evolve as the voice of Asia and the Pacific in international dialogue related to energy policies.
- ii. Cooperate and participate in establishing the Asia-Pacific Energy Agency, a special purpose public vehicle for promoting energy connectivity infrastructure.
- iii. Request the Executive Secretary of ESCAP to help finalize the charter and create the regional institutions for energy integration. ESCAP will need to establish the Preparatory Committee for energy connectivity. After initial discussions with member countries, a suitable timetable and process for creating the two bodies will need to be included in the Asia-Pacific Energy Charter.

The 2013 Ministerial Declaration has already taken the first step towards closer regional and subregional cooperation for promoting energy connectivity. There is already a significant level of trust among countries participating in existing subregional organizations. The Asia-Pacific Energy Charter will be the “enabling” agreement and indicate the commitment by member countries to consider specific measures for expanding energy connectivity towards the creation of subregional bourse and markets. It has to be recognized that energy connectivity programmes, projects, policies and governance structures will be designed so member countries benefit fully from regional energy trade. For plans to be converted into actual energy-trading, there has to be equitable sharing of costs and benefits between the participating countries — between energy producers and consumers, small and large economies, resource-rich and import-dependent countries, landlocked areas and archipelagoes, countries with robust energy companies and financial markets and those with little savings.

2. Asia-Pacific Energy Centre

Multiple agencies are currently collecting and collating regional and subregional energy information. While resources have been allocated, primary data are not being captured in a common format, data dissemination is delayed by several months, and often information from different sources lacks consistency. This hinders analytical work and makes it difficult to develop new and innovative policy options that may be more suitable for the Region. The proposed Asia-Pacific Energy Centre will fill the knowledge gap and build the regional expertise in energy policies and planning for energy connectivity. As knowledge grows, the regional expertise will also be useful in formulating national energy policies for sustainable energy use and increasing energy access.

The concerns of the Asia-Pacific Energy Centre will include the following,

- i. *Energy information and energy economics.* The Centre will assimilate and disseminate all energy-related data and reports of member countries. It will strive to build understanding of energy production and use in Asia and the Pacific, a region which includes many economies with high growth rates and rapid urbanization. This will include analysis of clean cooking fuel, which is a serious issue in most of Asia but gets little attention from international experts. One key to private sector investment is going to be timely information about energy production and use, and an outlook based on projections over a 10–15 year time horizon. Because projections involve assumptions, investors will want to build their own scenarios so the importance of readily available robust data cannot be understated.
- ii. *Energy policies.* The overall goal of sustainable energy use and energy access is going to be achieved by implementing sound policies. Analysis of policy options based on the available energy resources and demand projections will be of high value to decision makers. Close attention needs to be given to matters related to regional and subregional energy security, equitable sharing of costs and benefits of energy trade and markets, stakeholder analysis (winners and losers), clean energy and energy access for all; member countries will support energy connectivity when they better understand the issues and some options for resolving them. The regional centre will also emphasize measures for fully benefiting from the large renewable energy resources available in the Region and aggressively increasing energy efficiency. Thus it will help member countries shift to low-carbon and, eventually, zero net-carbon emissions as committed in international agreements.
- iii. *Clean technologies.* As the largest energy-consuming region in the world, Asia will need to acquire and gradually start developing suitable technologies for safety, low emission,⁴³ energy efficiency, affordability and storage. It could be argued that there are few industrialized countries in the

Region that currently have the capacity for developing new technologies; however, partnership and cooperation between the high energy-consuming countries will accelerate the deployment of energy storage, carbon capture and storage, biofuels, tidal power, etc. — the technologies needed after 2050 when member countries start decarbonizing the energy sector. The Asia-Pacific Energy Centre would encourage member countries to invest jointly in research and development of new technologies, and bring together international expertise as required.

- iv. *Knowledge-sharing and capacity-building.* The transformation of the energy sector in the Region will need significant capacity-building among stakeholders. They need to understand the implications of business-as-usual and the policy options linked to greater energy connectivity. The private sector and lenders also need to appreciate the value of providing public goods and the benefit to the economy and the society. The Asia-Pacific Energy Centre will play a key role in knowledge-sharing and capacity-building. In addition to the knowledge developed in-house, it will invite international experts and partner with other institutions to build capacity in the Region for dealing with future challenges. Information technology and modern communications can be used to develop virtual networks of experts that can effectively contribute towards stronger energy connectivity.
- v. *International decision-making.* Regular consultations with the United States and Europe, the other two large energy-consuming regions, will increase energy security for all.

3. Asia-Pacific Energy Agency

While several cross-border projects have been implemented in the Region, these followed an opportunistic approach. Useful lessons have emerged but these have not yet developed into a systemic approach that significantly lowers the time and transaction costs of dealing with multiple agencies and protracted negotiations. A professionally managed regional entity is proposed for focusing on implementation of cross-border energy connectivity infrastructure projects; it will ensure that all stakeholders (mainly governments, private sector and civil society) work towards a shared goal and create synergy.

The scope of the proposed APEA, a special purpose public agency, will include but not be limited to the following:

- i. Carry out pre-feasibility studies for transnational infrastructure. The existing subregional organizations⁴⁴ have already identified many possible projects that can be further refined to maximize benefits and lower costs.
- ii. Draft PPP contracts that reflect the requirements of bankable projects. While proposals for bankable projects will attract private sector developers and investors, the draft contracts will also balance the governance structures and requirements of the participating countries.
- iii. Use competitive bidding processes for procurement of consulting services and selection of PPP project developers who will implement transnational energy infrastructure. The current practice, wherein different entities implement portions of the project that are physically located in different countries, carries considerable implementation risks. The investment has zero value until the last interconnecting portion is in place so delays in any one country can add significant costs. Project implementation risk can be considerably lowered by bringing together all components — e.g. a hydropower project in country A, high voltage transmission lines in countries A, B and C, and interconnection with power grids in countries A, B and C.

- iv. Assist member countries in negotiating PPP contracts with project developers. Negotiating a balanced contract requires expertise in technical, legal, financial, economic, environmental and social aspects. It also requires an up-to-date knowledge of PPP contracts across the world.
- v. Maintain oversight during the project implementation phase and later, during the first five years of the operation phase — i.e. the time needed for the energy connectivity project to become an integral part of the energy systems of the participating countries.
- vi. Ensure that networks (oil and gas pipelines and power transmission lines) provide open access and cannot become barriers to competitive markets that will evolve when a number of transnational energy infrastructure projects are in place.
- vii. Mediate between parties when there is a dispute. The parties would have the right to seek arbitration under the PPP contract. However, it is generally possible to resolve most issues amicably using a mediator who clarifies the position of the parties.
- viii. Develop and help evolve suitable regional energy markets. Several bilateral interconnections already exist and more are under implementation and being developed. These extend the benefits of rich energy resource in a country with low demand (a low energy price) to a neighbouring country with a high demand but less energy resource (a high energy price) — for example, low-cost hydropower in Bhutan, Lao People's Democratic Republic, Kyrgyz Republic and Tajikistan being exported to Afghanistan, India, Pakistan and Thailand. Enabling multilateral trade will increase the benefits as a competitive environment will bring innovation and lower costs. Therefore, APEA will develop medium-term plans for setting up competitive markets and hubs wherein prices are set by supply-demand gaps and price signals are used to plan new investments. This shift would have been simple if the participating countries already had competitive wholesale markets. As this is not the case, initially the markets would have to be specifically designed for multilateral trading between national power and gas companies and private sector project developers. In the case of electricity interconnections, useful lessons can be drawn from power exchange taking place between different provincial and subregional grids within a country.
- ix. Coordinate with international financial institutions and bilateral donors that support regional cooperation and energy security. Loans from these institutions generally have a longer tenure than from commercial banks, which helps lower the energy tariff; their participation also lowers the risk profile and thus the cost of funds. However, it is important to satisfy the more stringent requirements of the development institutions, particularly regarding transparency and minimizing environmental and social impacts.

Considering the large size of the Region and the diversity within it, APEA will need to respond to different needs of subregions. It is envisaged that energy connectivity (electricity transmission lines, markets and natural gas pipelines) will initially strengthen the systems in the four subregions — South-East Asia, South Asia, Central Asia, and North-East Asia. The resource endowments and present policies and structures are varied so the member countries in some subregions may wish to adopt a more aggressive timetable for energy connectivity. For example, North-East Asia started collaboration more recently than other subregions but the private sector in Japan and large power transmission and gas companies in the Russian Federation have shown interest in developing the huge renewable energy resources and are supporting the Gobitec and Asian Super Grid proposals. With better support of subregional members, the projects in North-East Asia can, therefore, be fast-tracked.

A treaty among participating countries will be needed to establish the APEA and provide the legal basis for transferring to it some of the decision-making powers for cross-border PPP projects. The framework that guides the treaty's operations should enable project proposals to be developed within 2–3 years in order to attract private sector developers. After being prepared to an international standard, project proposals will be submitted for approval of participating governments. The treaty will also enable APEA to oversee project implementation and initial operations, thus ensuring technical quality, controlling cost and time overruns, and protecting the interest of the parties. However, the cross-border projects will be owned by the private sector and APEA will not invest directly in them.

The proposed role of APEA is similar to a consulting firm or investment banker, which is distinct from the role of a project developer or a bank. APEA will not own or lend for physical assets but will enable others to invest in cross-border energy infrastructure projects. Its success will be linked to the portfolio of bankable cross-border PPP projects it develops and the balance it achieves in sharing costs and benefits between countries and the private sector.

Justification and Challenges in Creating New Organizations

Asia-Pacific Energy Centre and APEA will aggressively pursue the vision of energy connectivity in the Region. Two organizations with clear mandates, autonomous structures and full-time professionals will be better equipped to address the challenges in implementing transnational energy projects and facilitate fair and equitable distribution of costs and benefits. Furthermore, the two organizations require different skill sets. The Asia-Pacific Energy Centre will require knowledgeable energy economists and statisticians who will generate policy options based on robust analytical work; on the other hand the APEA will require project management, procurement, financial, legal and negotiation experts who will develop a pipeline of bankable projects. Expecting one organization to perform both roles could leave serious gaps and weaken accountability.

Some would point out that the existing subregional cooperation organizations already have secretariats and some have functioning energy centres. These secretariats and centres have considerable knowledge and experience, so an alternative could be to improve their functioning and make them results-oriented. However, given the history of these secretariats and energy centres, it would be a considerable challenge to convert them to autonomous organizations that would work on areas beyond the subregion. The existing staff is likely to accept the new mandate, but their organizational structure is based on country representation and it will be difficult to overcome internal boundaries and work towards a shared objective of energy connectivity across the Region.

The main challenge for the two proposed new organizations will be in making them autonomous — such that all member countries will trust that the decisions and the advice will be in the interest of regional energy security. No member, irrespective of size or resource endowment, should have a perception that others are taking undue advantage. This assurance will require specific checks and balances in the governance of the organizations, their funding, selection of senior managers, location of offices, etc. Now governments are better informed about such organizational matters so it will not be difficult to design the autonomous organizations and negotiate with member countries to obtain their consent and support.

The Asia-Pacific Energy Centre will require funds from member governments, as its ability to earn revenue will be limited. If contributions are taken from the private sector, the Centre's neutrality could become questionable. Lessons can be taken from the IEA, which is funded by 29 member countries. Its annual budget was €26,612,200 (\$29,960,022) in 2014.⁴⁵ Contribution by members is based on a formula that takes into account the respective size of their economies. About 25 per cent of the annual budget is raised from sale of publications and about 33 per cent is through voluntary contributions from countries and energy stakeholders.⁴⁶ The IEA currently has 240 staff members.

The proposed Asia-Pacific Energy Centre will complement the IEA and thereby strengthen worldwide energy security. Duplication of all activities would be ill-advised. It is envisaged that the Asia-Pacific Energy Centre will eventually have about a third as many staff members as the IEA and so the annual budget will also be proportionately lower, or about \$10 million. During the first five years, as the organization is growing and building capability, the Asia-Pacific Energy Centre will be unable to attract voluntary contributions or earn revenue from the sale of publications like the IEA, so contributions from members will need to cover the full annual budget. An annual contribution totaling \$10 million from 53 APEF members is considered reasonable considering the role that the autonomous organization will be vested with.

It is difficult to identify an existing special purpose public enterprise on which to model the APEA. The existing power pools — oil and gas trading hubs — are markets that have a revenue stream based on the transactions that go through them. It will require a decade or more for APEA to start similar markets in Asia and, even then, specialist market operators will need to commit to carry out the commercial activities. At the same time, the activities of the APEA will be directly linked to implementation of physical infrastructure with high capital cost. The common practice in the PPP model is for interested parties to commence activities using their own resources (staff and funds); at the stage of financial closure these expenses are included as project development costs in the capital structure and recovered when the asset starts earning revenue. Therefore, the project development-related expenses incurred by the APEA could be recovered like other services charged to the project. Designing a lean organization and using efficient processes will lower costs. For example, with about 20 full-time professional staff members and a liberal budget for consulting services, a contribution of \$60 million will allow APEA to function effectively for the first five years.

The APEA will not take any commercial risks or make investments. Its main resource will be the professional staff and it will have a very small capital asset — i.e. mostly office facilities. Therefore, the member countries will only need to invest a small amount as equity and assume very little risk. During the initial five years, APEA will require grants from member countries and working capital loans to prepare the first few projects, and a regular revenue stream will begin when these projects are implemented. The PPP project developers will see considerable value in the use of the one-stop-shop approach because their transaction costs for developing transnational energy projects will be considerably lower.

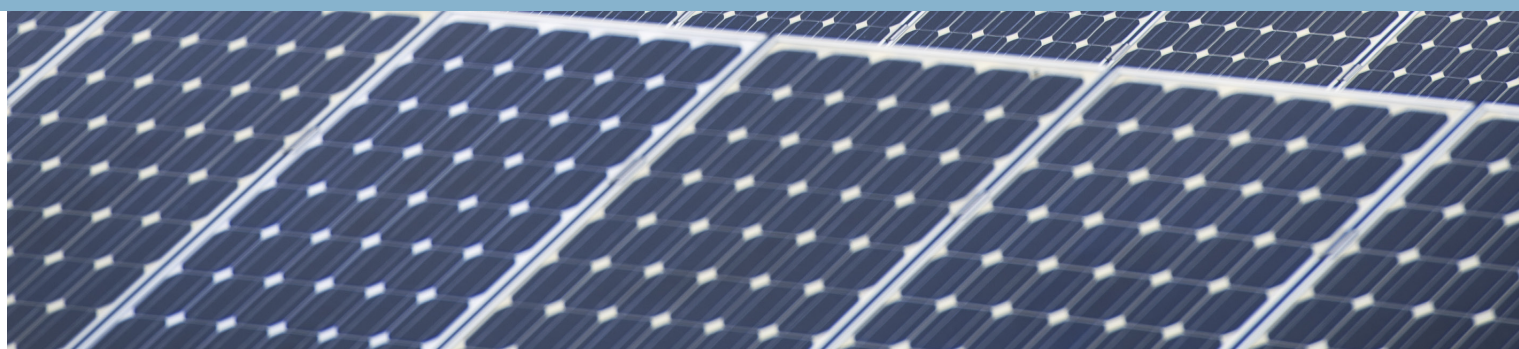
ESCAP, responding to the request by APEF, has already initiated steps to strengthen its energy capacity. The information and expertise sharing function is underway. After the APEF members give consent and endorse the vision of energy connectivity in the Region, ESCAP can aggressively lead the establishment of the two organizations. It will need to hold consultations with ADB, Asian Infrastructure Investment Bank, BRICS New Development Bank and Islamic Development Bank, which have specific provisions for providing technical assistance to entities in the region for developing infrastructure. The World Bank, European Bank of Reconstruction and Development and European Investment Bank also strongly support regional cooperation, including energy connectivity. Bilateral donors in the region,

such as the Japan International Cooperation Agency, are also expected to extend strong support for energy connectivity. Partnership with these institutions and member governments will help ESCAP raise resources for carrying out the initial activities linked to signing of the Asia-Pacific Energy Charter and establishment of the Asia-Pacific Energy Centre and APEA — mainly consulting services for drafting the documents (charter, articles of association), incorporation, organizational development and negotiation support.

Among the first critical decisions would be location of the headquarters of the two autonomous organizations. Some factors that will influence the decision would be: the attractiveness for international experts (e.g. availability of housing, medical and schooling resources, employment options for spouses); transparency and oversight required by the laws of the host country; connectivity for convenience of travel; availability of services that can be outsourced (e.g. office management, translation, local transport and information technology); and the possibility of forming a cluster with similar institutions and enhancing capacity. Most importantly, the choice of headquarters should not indicate a bias towards a particular member country that could weaken the autonomy of the organizations. The ability to deliver results will depend on the quality of staff and the innovative approaches they use to bring all stakeholders together for enhancing regional and subregional energy connectivity.



Appendices



Appendix 1. Subregional Energy Projects

Central Asia

Central Asia inherited the Central Asia Power System from the Soviet period. It included a load dispatch centre in Tashkent, Uzbekistan, and a single-circuit 500 kV transmission line connection in the southern part of Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan.

However, operational issues led to the disconnection of Turkmenistan in 2003 and Tajikistan in 2009. Now Tajikistan and Uzbekistan are connected to Afghanistan. Furthermore, north Kazakhstan

Table A1.1 CAREC Energy Connectivity – Electricity Projects

Project Name	Country(ies)	Project Cost (\$ Million)	Loan Approval	Status
Turkmenistan-Afghanistan-Pakistan-and India Natural Gas Pipeline Project (TAPI)	Turkmenistan, Afghanistan, Pakistan, India	10,000	^a	Inaugurated
Central Asia South Asia Electricity Transmission and Trade Project (CASA 1000)	Afghanistan, Kyrgyz Republic, Pakistan, Tajikistan	1,170	2014	Ongoing
Toktogul Rehabilitation Phase 2 Project	Kyrgyz Republic	252	2014	Ongoing
Golovnaya 240-Megawatt Hydropower Plant Rehabilitation Project	Tajikistan	170	2013	Ongoing
Regional Power Transmission Interconnection Project	Afghanistan, Tajikistan	112	2010	Complete
Regional Power Transmission Project	Tajikistan	141	2010	Ongoing
Talimarjan Power Project (formerly CASAREM-Talimarjan Energy Development Project)	Uzbekistan	1,280	2010	Ongoing
Nurek 500 kV Switchyard Reconstruction Project	Tajikistan	67	2008	Ongoing
Central Asia Power System	Kazakhstan, Kyrgyz Republic, Tajikistan, Uzbekistan		1991 ^b	Operational
Ekibastuz-Kokshetau Ultra High Voltage Line	Kazakhstan, Russian Federation		1991 ^c	Operational

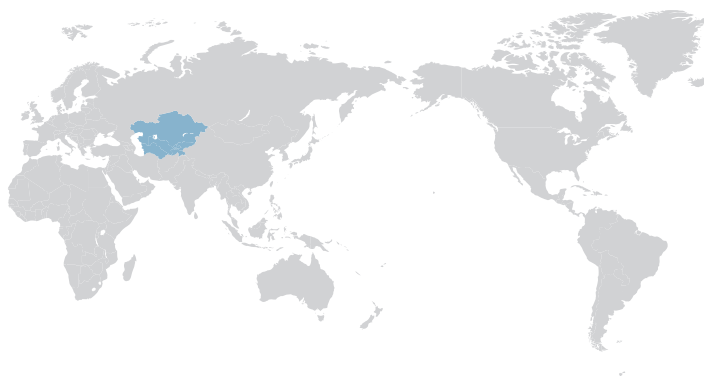
^a TAPI project was identified about 25 years ago; agreements are in place and a consortium of national gas pipeline countries will implement the project.

^b The subregion is interconnected with a 500 kV transmission system that is a legacy of the Soviet period.

^c The voltage level of the interconnection is 1,150 kV, the highest in the world. It was also completed during the Soviet period.

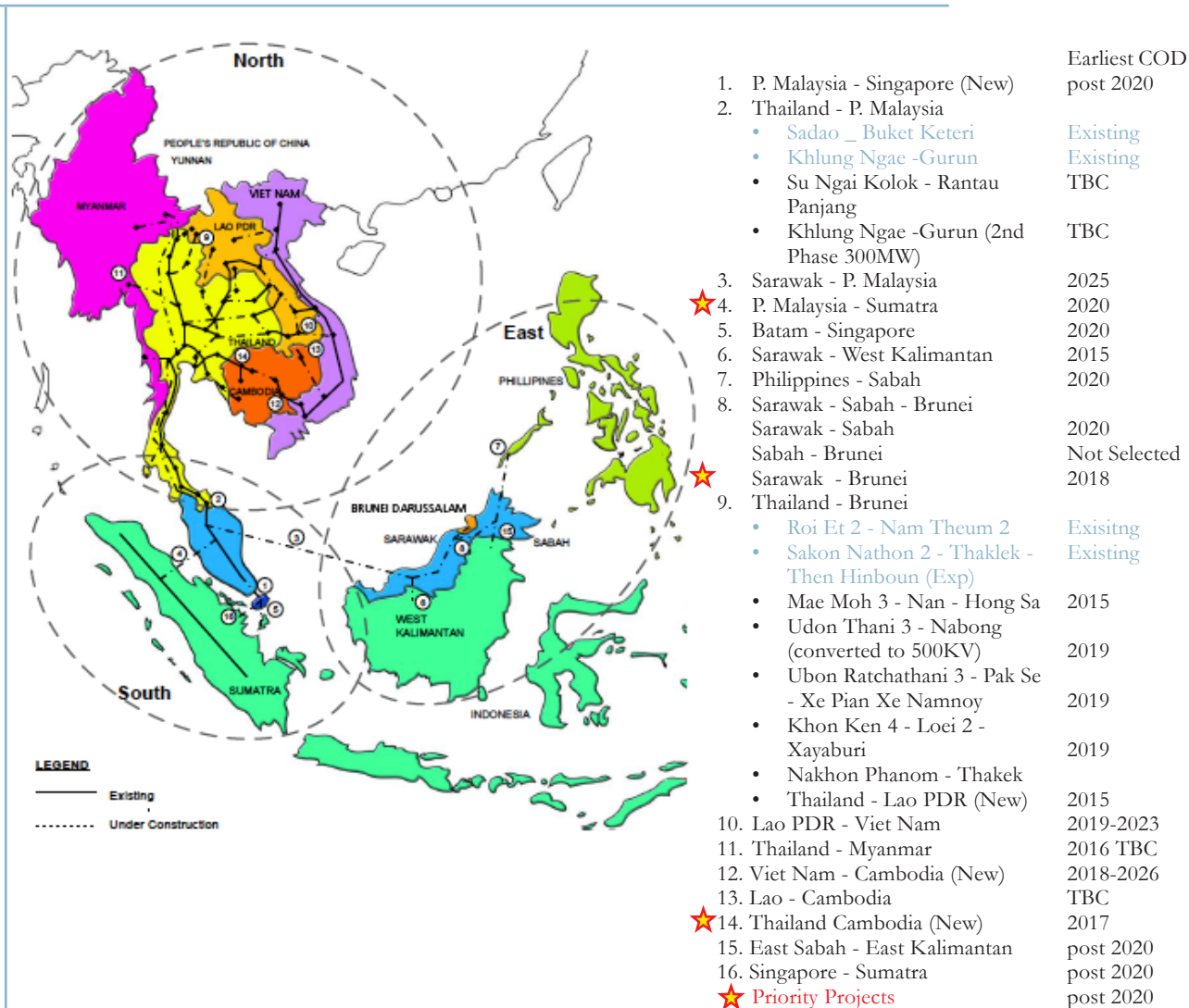
Source: www.carecprogram.org, the World Bank and others.

was connected to the Russian Federation. Table A1.1 lists the major interconnection projects in the electricity sector that were developed after the countries became independent; it includes upgrade and renovation projects to strengthen electricity trade.



Central Asian countries also inherited a gas transmission system that extended gas supplies from Uzbekistan to southern Kazakhstan, Kyrgyz Republic and Tajikistan. However, the system lacks maintenance and many sections are abandoned or work at a very low pressure.

Figure A1.1 ASEAN Energy Connectivity - Electricity Projects



Source: ASEAN Plan of Action for Energy Cooperation (APAEC) 2016 – 2025. September 2015.

Disclaimer: The boundaries and names shown and designations used on this map do not imply official endorsement or acceptance by the United Nations.

Table A1.2 Completed Bilateral Gas Pipeline Interconnection Projects

Pipeline Interconnections	Length (km)	Year of Operation
1. Singapore - Malaysia	5	1991
2. Myanmar - Thailand	470	1999
3. Myanmar - Thailand	340	2000
4. West Natuna, Indonesia - Singapore	660	2001
5. West Natuna, Indonesia – Duyong, Malaysia	100	2001
6. Malaysia/Viet Nam CAA - Malaysia	270	2002
7. South Sumatra, Indonesia - Singapore	470	2003
8. Malaysia/Viet Nam CAA – Viet Nam	330	2007
9. Malaysia – Thailand/Malaysia JDA	270	2005
10. Singapore - Malaysia	4	2006
11. Thailand/Malaysia JDA - Thailand	100	2009
12. Zawtika Block M9, Myanmar - Thailand	302	2013
13. Thailand/Malaysia JDA Block 17 – Kerteh, Malaysia	352	2015

CAA = Commercial Arrangement Area; JDA = Joint Development Area

Table A1.3 Regasification Terminals in ASEAN

Pipeline Interconnections	Capacity (MTPA)	Year of Operation
1. Map Ta Phut LNG Receiving Terminal, Thailand	5	2011
2. West Java FSRU, Indonesia	3	2012
3. Singapore LNG	6	2013
4. Sungai Udang, Melaka, Malaysia	3.6	2013

LNG = liquefied natural gas; MTPA = million ton per annum; FSRU = floating storage and regasification unit

Source: ASEAN Plan of Action for Energy Cooperation (APAEC) 2016 – 2025, September 2015.

South-East Asia

South-East Asia has two flagship programmes under the Association of Southeast Asian Nations (ASEAN) in the energy sector, the ASEAN Power Grid and the Trans-ASEAN Gas Pipeline. The ASEAN Plan of Action for Energy Cooperation (2016-2025) lists 16 projects interconnecting different countries (Figure A1.1). Six interconnections have been completed for bilateral power trade between Singapore and Peninsular Malaysia, Thailand and Peninsular Malaysia, and Thailand to Cambodia, Lao People's Democratic Republic and Viet Nam. Discussions have also been initiated regarding multilateral trade between Lao People's Democratic Republic, Thailand, Peninsular Malaysia and Singapore.



Bilateral gas trade in the ASEAN subregion uses pipelines and liquefied natural gas (LNG) regasification terminals. Table A1.2 lists the pipelines and Table A1.3 lists the regasification terminals.

South Asia

South Asia has limited cross-border energy interconnection capacity. The largest number of interconnections are between India and Nepal — three lines operating at 132 kV, nine at 33 kV and six at 11 kV. As the voltage level is low, the line capacity is also low; the two systems do not operate

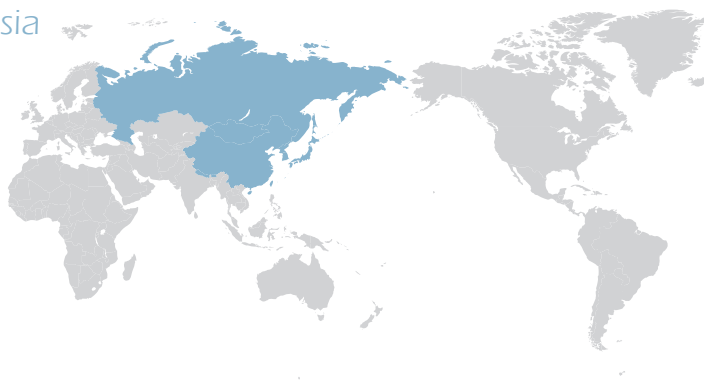
synchronously. A new 400 kV transmission line is being implemented between Muzaffarpur, India, and Dhalkebar, Nepal, at an estimated cost of \$48 million. After completion the power transfer capacity will be above 500 MW, though the expected import by Nepal is 150 MW. Later, when new hydropower capacity is developed in Nepal, India will be able to import clean power.

Bhutan and Bangladesh are connected to the Indian power system. India has provided assistance for implementing three hydropower projects in Bhutan totaling 1,400 MW capacity, and another four projects with 3,000 MW capacity are under implementation. These projects export power to India on a bilateral basis. Bangladesh and India are interconnected with a 400 kV transmission line of 500 MW capacity, which is being doubled by adding a second circuit.



North and North-East Asia

Mongolia imports about 160 MW from the Russian Federation and from the People's Republic of China (PRC) for the large mines in southern Mongolia. PRC imports power from the Russian Federation through a 500 kV transmission line.



PRC has implemented three pipelines for importing 55 BCM gas annually from Turkmenistan and a fourth line with a capacity of 30 BCM is under implementation. Another line imports 12 BCM gas annually from Myanmar and PRC is implementing a pipeline for importing 30 BCM gas annually from eastern Russia.

Appendix 2. Project CASA 1000 – High Transaction Costs

In March 2014, the World Bank approved assistance of \$526.5 million for the implementation of the Central Asia South Asia Electricity Transmission and Trade Project (CASA 1000). The project cost was estimated at \$1,170 million; it included the implementation of 750 km of 500 kV high voltage direct current transmission line, three convertor stations (1,300 MW capacity in Tajikistan and Pakistan, and 300 MW capacity in Afghanistan), 475 km of high voltage alternate current transmission line and substations, and grid reinforcement in Tajikistan. Also included in the estimated project costs was \$120 million for project implementation support, community support programmes and environmental and social costs. The Islamic Development Bank has provided \$250 million, the four participating governments (Afghanistan, Kyrgyz Republic, Pakistan and Tajikistan) will provide \$134.5 million, and bilateral donors, including Australia, United Kingdom and the United States, have committed to fill the financing gap.

The project development objective is to create conditions for sustainable electricity trade between Central Asian and South Asian countries. The participating governments have committed to create suitable mechanisms for contributing part of the project benefits to directly support the poor and vulnerable communities along the route of the transmission line. The project's economic internal rate of return (EIRR) is estimated at 26 per cent and the financial internal rate of return (FIRR) is estimated at 25 per cent. The benefits will be 10 per cent and 9 per cent, respectively, even in the worst case scenario (i.e. 30% higher project cost, 30% less surplus energy being exported, 30% lower tariff and two-year implementation delay).

The Inter-Governmental Council (IGC) decided that the respective governments would implement the project in the public sector through the national transmission companies. There are several sources of finance and the recipient countries have signed the respective loan agreements. Establishing a separate legal project company was not preferred because it would be time-consuming and there was little prospect of private sector investment. Project implementation risks are being addressed by creating an intergovernmental joint working group, secretariat, finance and procurement committees, appointing a procurement consultant and hiring two owner's engineers for the main technologies, i.e. transmission line and convertor stations.

The construction of 1,225 km of high voltage transmission line and related substations in sparsely populated regions is normally considered a routine project. The electricity trade is also strongly justified because it transfers surplus energy that is presently spilled from existing reservoirs during the summer season in Central Asia to fill the supply shortages in Afghanistan and Pakistan. A special concern for CASA 1000 is that it passes through conflict-prone regions, which is being addressed by including an extensively discussed and participative community support programme during implementation and continuing throughout the operation period. Because the electricity trade is based on surplus energy, the quantity is divided into tier 1 (firm) and tier 2 (variable) for better clarity.

However, the project has a high transaction cost because there are multiple loans, procurement guidelines, implementing companies, contract packages and power purchase agreements. International lenders, equipment suppliers, consultants and operation and maintenance contractors (for the convertor stations) need to deal with multiple agencies, several of which will be in a learning phase with respect to implementing large power transmission projects.

The transaction cost for developing the project has been quite high. The following timeline reflects the efforts put in to develop the project.

(i) December 2004: The concept of trading hydropower from Central Asia to South Asia was initially proposed in the World Bank staff report titled “Central Asia Regional Electricity Export Potential Study”. It identified potential for additional hydropower generation capacity of over 6,800 MW (mostly from partly implemented projects from the erstwhile Soviet period) that can sell power to South Asia on a competitive basis. Both the Asian Development Bank and the World Bank engaged the four participating governments to establish the framework for electricity trade that was seen as a “win-win” proposition.

(ii) December 2006: Asian Development Bank provided technical assistance of \$3 million for phase 1 (pre-feasibility) and phase 2 (full feasibility) to develop the project. The participating countries entered into a formal agreement in August 2008 to set up the Inter-Governmental Council and secretariat to steer the development of the project. However, in February 2009, the Asian Development Bank suspended its participation as a potential lender because it had given a higher priority to emergency assistance following the 2008 financial crisis and there was slow progress in finalizing the commercial agreements between the countries.

(iii) December 2006: Asian Development Bank approved assistance for a related \$109 million project comprising 275 km of 220 kV double circuit transmission line from Tajikistan to Afghanistan to export up to 300 MW of power. This project has been completed and it exported 791 GWh in 2013 (peak of 200 MW). The validation report prepared in November 2014 by the bank’s Independent Evaluation Department found the project to be satisfactory.

(iv) September 2011: The participating countries signed a memorandum of understanding and approved the minutes of the meeting in Bishkek that requested assistance from the World Bank for preparation of the Environmental and Social Impact Assessment and Management Plan.

(v) 2011: The World Bank provided support to update the feasibility report for CASA 1000 and preparation of the Environmental and Social Impact Assessment and Management Plan (contract amount has not been disclosed on the Internet website).

(vi) 2012: The four countries signed a Financial Advisory Service Agreement with the International Finance Corporation for the selection of the developer and operator of the project.

(vii) March 2014: The project gained approval for World Bank assistance. The project implementation is scheduled to be complete by December 2019.

(viii) 2016: Procurement is in progress. Prequalification of vendors for the transmission lines in Kyrgyz Republic, Pakistan and Tajikistan is in progress, the invitation of bids is expected in mid-2016.

In addition to the contractual expenses, the project development also required significant effort by staff of the World Bank, Asian Development Bank, Islamic Development Bank, bilateral donors and the four participating governments. The institutions and governments do not disclose the level of effort used for developing individual project proposals, but a rough estimate indicates about 300 person-months has been used over the last ten years, which would generally cost over \$5 million.

Figure A1.2 Map of CASA 1000



Source: www.casa-1000.org

Disclaimer: The boundaries and names shown and designations used on this map do not imply official endorsement or acceptance by the United Nations.

Appendix 3. International Experience – Gas and Electricity

Energy connectivity involves cross-border wholesale gas and electricity transactions that may be market-based, reflecting demand-supply deficit or surplus, or through administrative processes based on cost of providing service. Gas and electricity cannot be seen but they can be metered and supply can be turned off, which makes it possible to trade them like other commodities. Furthermore, there are physical markets that require delivery and off-take of gas and electricity, and financial markets that exchange derivatives linked to the physical market.⁴⁸ Trading energy derivatives brings in additional funds from investors for operations and long-term investment in the energy sector. More recently, carbon emission has been commoditized so it is becoming a policy instrument for lowering greenhouse gas emissions, and when large investors participate in carbon emission trade, there will be new capital for implementing zero-carbon energy capacity.

To better understand the likely path of energy connectivity in Asia and the Pacific, a brief description of wholesale electricity and gas transactions is provided.

Wholesale Gas Transactions

Wholesale natural gas transactions are done either using liquefied natural gas (LNG) or across pipelines. LNG is natural gas cooled to minus 162 degrees Celsius, which reduces the volume by 600 times. Once liquefied, trucks or ships with cryogenic or insulated tanks can transport it to places not connected by pipelines. Regasification and storage facilities are needed at the receiving end before the fuel can be used. Pipelines, liquefaction, regasification and storage facilities are capital-intensive. Transportation of gas through pipelines generally costs less, as long as it does not involve long submarine routes.

When wholesale markets are absent, pipeline gas transactions — and LNG trade to a lesser extent — require long-term contracts that lock the buyer into paying for a minimum quantity of gas annually at an agreed price. Lenders seek an assured revenue stream when appraising large loans for creating the necessary assets for production and transportation of the gas. Though secure, the transaction lacks flexibility and competition. The buyer is unable to look at alternate sources of supply or significantly increase the demand, and the producer gets paid on the basis of cost recovery rather than benefiting from a supply-demand gap. In general, such transactions tend to be conservative and less efficient.

In the United States and Europe, wholesale trade of natural gas is market-based like other commodities, which involves both physical and financial markets. The physical gas market may involve transfer of ownership at hubs or the balancing of supplies and trades across a gas transportation network.

Gas hubs get created at the meeting point of pipelines from several production and demand centres. These hubs also need gas storage facilities for matching demand and supply. The storage may be geological (underground) or in tanks. To be traded as a commodity, all gas entering the pipeline system has to be treated to limit impurities (dry gas). The gas pipelines are pressurized; the high-capacity lines have pressure over 100 bar. Automatic gas leak detection and location systems are important for pipelines to avoid loss, ensure safety, and prevent greenhouse gas emission;⁴⁹ the same systems are useful for reducing loss and speeding recovery in case a pipeline is damaged for any reason, including sabotage. The gas pressure at the power plant boundary, or at the receiving station of gas distribution companies, is decided by contract agreement and is generally from 30 bar to 40 bar.

Unlike in the United States and Europe, there are no established gas markets in Asia and the Pacific region. Japan and the Republic of Korea are the two largest demand centres for gas. Both countries need to import gas as LNG because there are no pipelines from production centres. Japan's regasification capacity is 184 million tons per annum (MTPA), the largest

in the world, and the Republic of Korea's regasification capacity is 92 MTPA.⁵⁰ The LNG price has been benchmarked against the average monthly price of crude oil imported by Japan; this method of oil indexation was introduced in the 1970s when Japan started importing from Abu Dhabi and Indonesia under long-term supply contracts. The United States and Europe have priced LNG according to competing fuels. In the United States it competes with pipeline gas and is benchmarked against the Henry Hub price for domestic spot transactions; in Europe it is benchmarked against fuel oil and natural gas spot prices. The difference in approach has created a significant premium for LNG in the Region since 2010, when availability of shale gas depressed the pipeline gas price in the United States.⁵¹

The Region has only a few cross-border gas pipelines. The notable pipelines allow China to import gas. The Central Asia–China gas pipeline runs from Gedaim in Turkmenistan, through Uzbekistan and Kazakhstan, to Horgos in China's Xinjiang Uygur Autonomous Region. Chinese and Turkmen state-owned enterprises have jointly explored and developed the gas fields, and have a contract to supply 55 BCM of gas annually for 30 years. The construction of three pipelines, each 1,833 km, started in August 2007 and all became operational by May 2014. Construction of the fourth line, with additional 30 BCM per annum capacity, which transits through Uzbekistan–Tajikistan–Kyrgyz Republic, is also underway. The Myanmar–China 2,520 km gas pipeline, with a capacity of 12 BCM per annum, became operational in October 2013. Furthermore, China started construction of the Eastern Russia–China gas pipeline for importing 5 BCM per annum from 2018 (the volume will increase to 30 BCM per annum from 2023). The length of the Chinese part of the pipeline is 3,170 km, which extends to Shanghai, and the Russian part is the 2,680 km Power of Siberia gas system connecting the Irkutsk region to Vladivostok. The agreement includes cooperation in gas exploration and production between Russian and Chinese companies. China also has an agreement for buying 3 MTPA of LNG from the Yamal terminal on the Arctic coast of the Russia Federation.⁵²

It is evident that China has made significant headway in assuring gas supplies. It also benefits from comparison between imports using pipeline gas and LNG. However, the agreements were led by the governments so they do not reveal the market price of gas, and both sides are locked into 30-year contracts. Other countries may not be able to learn much from these projects when using a public-private partnership (PPP) approach and commercial financing for implementing cross-border gas pipeline projects.

Singapore imports gas from neighbouring Malaysia and Indonesia through pipelines. It is also implementing LNG regasification and storage facilities that will have a capacity of 11 MTPA by 2018. The terminal provides open access and facilities to store and re-export. There are also plans to implement another LNG terminal.⁵³ Potentially, Singapore could become a regional gas hub in the future.

Wholesale Electricity Transactions

A wholesale competitive electricity market requires a system operator to ensure that demand is met continuously and instantaneously. Maintaining an adequate reserve margin in electricity generation and transmission capacities ensures the reliability of electricity service. Very often, distinct from the electricity flows, the wholesale buyers (large consumers, aggregators or distribution companies) may be paying the wholesale electricity suppliers (either producers or aggregators) according to separate contractual agreements. The market-clearing price during any trading interval is then used to price the unscheduled interchange, which cannot be avoided because electricity flows follow laws of physics and

cannot be dictated by commercial contracts. Close market supervision is necessary to detect gaming — e.g. when suppliers hold back capacity to increase the market clearance price, or participants collude and use market power to their advantage.

Without a market, the general practice in the electricity sector, particularly in the Region, has been to use administrative processes for allowing addition of new supply capacity and approving the tariff — i.e. the rate that enables recovery of full cost and reasonable profit. The private sector has actively added new power generation capacity in several countries, wherein the decision has been subject to regulation or competitive tendering process. Addition of generation capacity using renewable energy is based on avoided cost and, more often, feed-in-tariff that is set administratively.

The drawback of using administrative processes to regulate private sector investments is the challenge in striking the balance between the interests of investors and consumers. Timely addition of new capacity requires attractive returns on investment, but at the same time, a high tariff level may discourage industry from producing goods or households from availing themselves of services. Furthermore, the Region has only a few private sector enterprises that have a track record in managing utility business; many lack the long-term perspective matching the life of energy sector assets. They prefer short- and medium-term investments that are high risk/high return ventures instead of assured incomes over several decades with minimal competition; most do not appreciate the need for regulation or the extensive reporting requirements, and incumbents benefit from gatekeeping. As a result, only a few domestic enterprises show interest when governments seek PPP in the energy sector. The private sector expects high returns when it invests and it also wants the government to share significant risks. In many countries where the private sector is weak, addition of new capacity has been delayed, which often constrains economic growth and limits access to energy for communities in rural and remote regions. In some countries private sector investment is being hurt because of low end-use tariffs that do not reflect the full cost of supply.

The problem with private sector participation is less of an issue for cross-border energy infrastructure, as state-owned enterprises from other countries are treated as private sector players. In the present environment, state-owned utilities, with demonstrable technical and managerial capacity, will find it easier to raise funds for implementing energy connectivity infrastructure. As opportunities increase, the private sector companies will be attracted and will value the low but stable returns, thereby preparing the ground for wholesale competitive markets and power pools.

Energy security in the Region is going to depend significantly on the ability to attract additional capital for the infrastructure needed to meet the rapid growth in energy demand. Addressing this risk would require a gradual progression from administrative processes, where governments are involved in the decisions for implementing incremental supply capacity, to physical markets that establish competitive pricing to attract additional investments. When physical markets mature, energy derivative markets will get started and attract the general savings in the economy. In the final stage, instead of exercising direct control over incremental supply capacity, the governments will only need to lay down the market rules and market supervision arrangements. The United States and Europe have developed along this path and are effectively managing the energy supply risks. Now that the Region is the largest energy-consuming region, regional energy security will also require a similar pathway for assuring that the savings in the economy is appropriately invested in the required growth of the energy sector.

There are already examples of wholesale competitive electricity markets in Asia, i.e. Singapore and the Philippines have moved out of administrative processes for adding new supply capacity and expect investors to follow the market-clearing price for planning new investments. The large economies, namely

China and India, have interconnected provincial power grids and also carry out exchange between the subnational power grids.

Subregional Initiatives for Energy Connectivity

The main subregions have ongoing initiatives for promoting regional cooperation that includes energy security. The initiatives with identified energy components are:

- i. Association of Southeast Asian Nations (ASEAN) has a sectoral ministerial body, namely the ASEAN Ministers on Energy Meeting (AMEM), which is implementing the ASEAN Power Grid (APG) and the Trans-ASEAN Gas Pipeline (TAGP);⁵⁴
- ii. Of the 21 members of Asia-Pacific Economic Cooperation (APEC), 17 economies are in the Region; the APEC Energy Working Group is one of 15 working groups. The Energy Trade and Investment Task Force facilitates cooperation and promotes regional energy trade and investment liberalization;⁵⁵
- iii. Greater Mekong Subregion (GMS) has a four-staged approach for establishing a competitive electricity market;⁵⁶
- iv. Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA) includes power transmission lines between Sarawak in Malaysia and West Kalimantan in Indonesia, and between Sarawak and Brunei Darussalam;⁵⁷
- v. Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT) plans to implement a submarine power interconnection between peninsular Melaka (Malaysia) and Sumatra (Indonesia);⁵⁸
- vi. Central Asia Regional Economic Cooperation (CAREC) aims to, inter alia, secure energy through stronger integration of energy markets and promote economic growth through energy trade;⁵⁹
- vii. South Asian Association for Regional Cooperation (SAARC) has developed the concept of Energy Ring and regional power market;⁶⁰
- viii. South Asia Subregional Economic Cooperation (SASEC) has a strategy to improve cross-border electricity transmission and increase power trade;⁶¹
- ix. Pacific Island Forum (PIF) has the Framework for Pacific Regionalism for strengthening cooperation among members in various areas including climate change and economic growth;⁶²
- x. Northeast Asia Peace and Cooperation Initiative (NAPCI) is a recent initiative of the Republic of Korea that is discussing cooperation on issues such as oil hub, gas trading hub and super grid;⁶³ and
- xi. Eurasian Economic Union (EAEU) has signed a treaty in 2014 that aims to gradually create common markets for oil and petroleum products, gas and electricity.

Educational and research institutions in Australia, India, the Republic of Korea, the Russian Federation, Singapore and the United States (Hawaii) have carried out analytical and modelling work related to energy connectivity and have shared their findings widely. Similarly, large power transmission companies such as China Southern Power Grid (Chinese grid company) and Rosseti (the Russian grid company) have analysed candidate interconnection projects. International financial institutions have supported project preparatory work for a long time and provided assistance for some high profile regional interconnection projects.

Clarification must be made regarding the private sector in the context of cross-border investment. State-owned enterprises from one country will be considered private sector companies when doing business in another country. For example, the government of France owns 84.5 per cent of the shares of the EDF Group, which is the largest shareholder of the Nam Theun 2 Power Company, and the Chinese government-owned State Grid led a consortium of bidders in 2008 to win by auction a 50-year franchise for managing the National Grid Corporation of the Philippines. These state-owned enterprises are not treated any differently than private sector companies in the country of operations.

International Experience with Gas and Electricity Trade

Asia and the Pacific region are late in establishing energy connectivity, but this also offers the opportunity to learn from international experience. A desk review of some gas and electricity trading arrangements was done to understand their relative trading volumes, approach for determining price, and institutional arrangements, particularly how participating governments share their authority when considering new infrastructure proposals. Also important was whether evaluation has shown that the markets strengthened energy security for participating countries. Brief descriptions of three gas and four electricity markets are provided here:

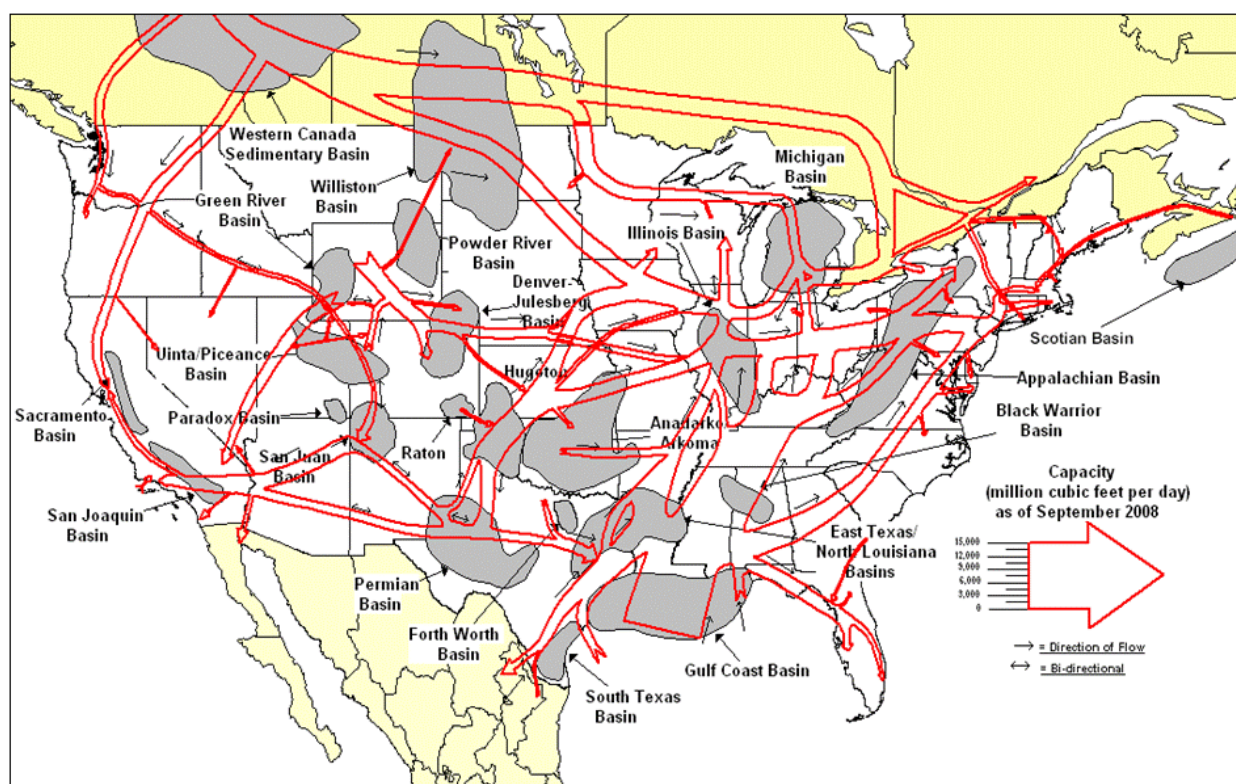
1. Henry Hub in the United States

The world's largest consumer and producer of natural gas is the United States. The natural gas infrastructure is immense. In 2014, gas consumption in the United States was 26.7 trillion cubic feet (TCF) or 756 BCM, and gas production was 25.7 TCF or 729 BCM. In comparison, gas consumption in Asia was 647 BCM, in Commonwealth of Independent States it was 642 BCM, and in Europe it was 480 BCM; the gas consumption in the world was 3,505 BCM. The consumption of gas in the United States is highest during the winter heating season; consumption during summer months drops to about 57 per cent as compared to the winter months. The large variation is managed by a large gas storage capacity (8.2 TCF or 233 BCM) available in underground mines, depleted reservoirs, aquifers and salt caverns.

The United States has over 3.86 million km of underground gas pipeline network, which includes 483,000 km of gas transmission pipelines (Figure A3.1). Gas transportation is regulated in the United States. Open access is provided to all gas suppliers and buyers and the pipeline company does not own the gas. The tariff to be charged by the pipeline company is determined by the Federal Energy Regulatory Commission.

The wholesale gas market was completely deregulated in the United States in 1993 and since then the market determines the wellhead price or the "first sale" to local distribution companies, large consumers

Figure A3.1 US Natural Gas Supply Basins and Major Pipeline Transmission Corridors-2008



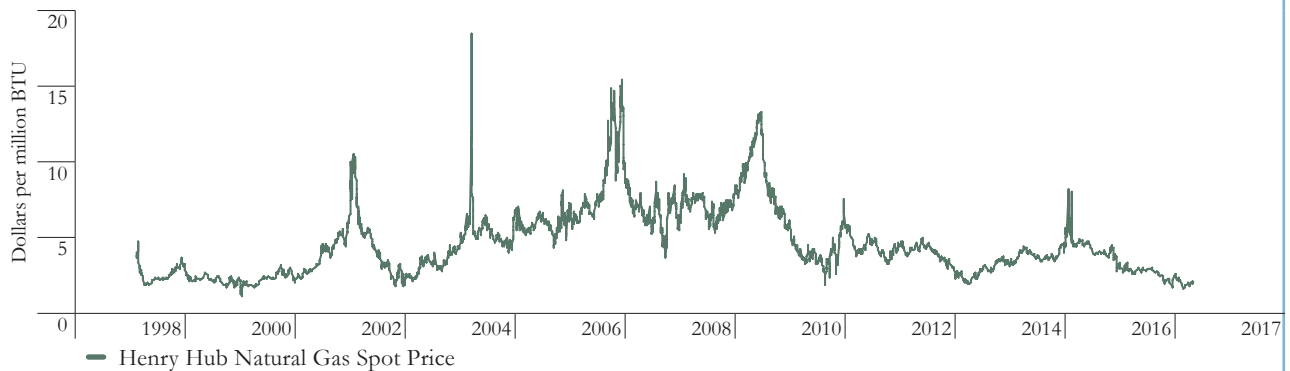
Source: US Energy Information Administration.

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and intermediaries. Producers supply some of the gas to local distribution companies under long-term contracts; however, most gas is physically sold at over 20 major hubs. The Henry Hub is strategically located in Louisiana, and has the capacity to transport 51 million cubic metres per day (about 2.5% of the total US gas consumption). In the daily market, gas is traded in the morning (by 11:30 Central Time) for delivery the next day. The transactions are finalized by matching quantity and price offers and bids, without identifying the seller or the buyer. The information is released immediately to ensure complete transparency. The daily spot price is the weighted average price. Gas is also traded in a monthly market that is based on the average price during the last five working days of the month and applicable to the sales during the following month. The Henry Hub price is used as the benchmark for transactions at other hubs and, more importantly, the New York Mercantile Exchange (NYMEX) future gas contracts (up to 18 months ahead) are settled at the Henry Hub. Furthermore, the Intercontinental Exchange (ICE), a global network of regulated exchanges and clearing houses, also trades future contracts based on NYMEX future gas contracts. These derivatives enable traders and investors to hedge the risks.

The average spot gas price at Henry Hub in 2014 was \$4.32 per million British thermal unit (MMBtu) or \$152 per thousand cm. At the other trading hubs, it was 14 per cent to 43 per cent higher.⁶⁴ The trend of the Henry Hub spot price over the past 18 years is given in Figure A3.2. The monthly average spot price has remained between \$2.6 per MMBtu and \$2.99 per MMBtu and is expected to remain at the same level, according to the futures contracts.

Figure A3.2 Henry Hub Daily Gas Spot Price



Source: US Energy Information Administration

Production of shale gas increased from 5 per cent of the total gas production in 2006 to 40 per cent in 2013. Shale gas production uses horizontal drilling and hydraulic fracturing technologies. This development not only increased domestic gas supplies and so obviated LNG imports, but also lowered the domestic gas price.

Export of natural gas from the United States is controlled; approval has to be given by the Department of Energy. It is the only regulation that has an impact on wholesale gas prices. In view of the recent low domestic gas prices, five LNG export terminals with an aggregate capacity of 9.22 billion cubic feet (BCF) per day (equivalent to 261 million cubic metres (MCM) per day) have been approved and are under construction; another three export terminals with an aggregate capacity of 5.13 BCF per day (145 MCM per day) have been approved but construction is yet to start.

In 2013, natural gas consumption accounted for 27 per cent of the total energy use in the United States and is projected to increase to 29 per cent by 2040. The net electricity generation increased from 4,040 terawatt hours (TWh) in 2005 to 4,076 TWh in 2014; during the same period — i.e. when shale gas production took off — the share of coal-based net electricity generation dropped from 50 per cent to 38 per cent, and that of gas increased from 19 per cent to 28 per cent. The policies, industry structure and free trade have undoubtedly been major factors in ensuring that timely investments are made in developing technology and increasing supplies, while prices remain checked. Increasing the share of gas for electricity generation has also been environmentally friendly, as emissions, including greenhouse gas emissions, are lower than from coal-based power generation.

2. Britain's National Balancing Point

Natural gas consumption in Great Britain was 63.76 BCM in 2014. As in the United States, gas is used extensively for heating, so the monthly consumption during summer season drops to about 45 per cent of winter consumption. The seasonal variation is mainly managed by the offshore depleted gas field storage with a capacity of 3 BCM; there are also another six medium-term storage locations (mostly salt caverns) with a capacity of 1.22 BCM. Buffering is also possible in the four LNG terminals having an aggregate capacity of 146 MCM per day, an annual capacity of 53.3 BCM that is 84 per cent of the annual gas consumption.⁶⁵ The production of offshore gas has been declining and in 2014 its share was only 58 per cent (as compared to 65% in 2010). There are five gas pipelines for import of gas from Norway and the Netherlands, one interconnector with Belgium that can carry gas both ways, and two lines for export to Ireland and Northern Ireland.

Figure A3.3 National Transmission System, UK



Source: Department of Energy and Climate Change, UK.

Disclaimer: The boundaries and names shown and designations used on this map do not imply official endorsement or acceptance by the United Nations.

The National Transmission System (NTS), the wholesale gas transportation system (Figure A.3), is owned and managed by National Grid, a public company registered in the United Kingdom. The company operates both the gas and electricity transmission systems in Great Britain (England, Scotland and Wales). It was established in the 1980s when the government privatized the British Gas and Central Electricity Generating Board but the government sold all its shares very soon. Only three investment firms own more than 3 per cent of National Grid shares; the voting power of the largest shareholder is 5.21 per cent. Large institutional investors, comprising 0.032 per cent of the total number of shareholders, own 86.2 per cent of the shares and 78 per cent of the shareholders own less than 500 shares out of a total of 3.9 billion shares.⁶⁶

National Grid is the sole system operator of the NTS and the electricity grid but it does not own the gas or electricity. The Office of Gas and Electricity Markets in the United Kingdom regulates the tariff for the system operator services. The company also owns four of the eight local gas distribution networks in the United Kingdom, but it is only paid for the transportation service, as the gas is owned by suppliers. National Grid also conducts electricity and gas business in the northeastern part of the United States.

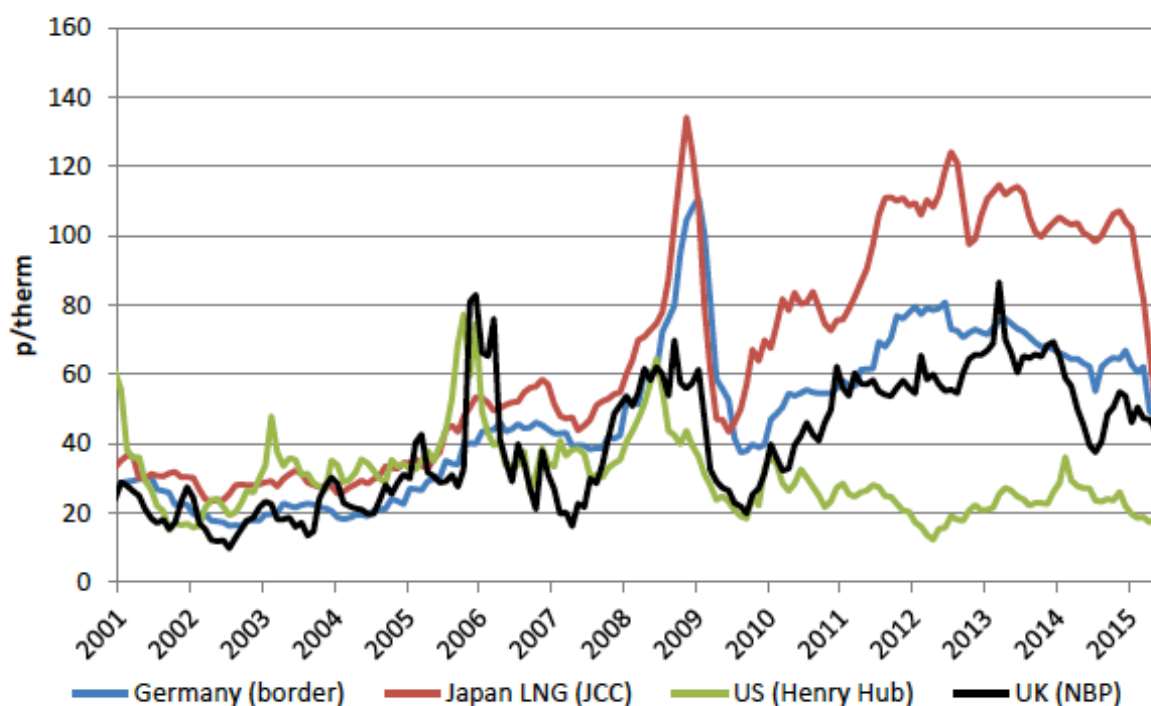
Wholesale gas is traded according to the virtual National Balancing Point. Every day, all participants balance the combination of physical and traded positions — i.e. the gas they supplied to and withdrew from the NTS and the gas they bought and sold. In case there is a shortfall, the system operator imposes

“cash-out” charges that reflect the cost incurred for balancing the system and ensuring that the party with the imbalance is left worse off. Gas is supplied by producers and importers (through pipelines and LNG) and withdrawn by large consumers — suppliers that sell it to end consumers and exporters, who participate in the wholesale competitive gas market. Trading houses and financial institutions also carry out trade for managing risks, optimizing assets, and acting as intermediaries for smaller companies that lack the expertise to trade. The liquidity of the wholesale gas market is indicated by the “churn” ratio — i.e. the number of times a unit of gas is traded before being utilized; this was an average of 25 in 2014 (a ratio of 10 is considered the minimum for a mature market).

Participants are free to choose how they trade and whom to trade with. For any given day, the trade can be done before or on the day. ICE offers future contracts for various time frames; the longest is for four seasons ahead. The wholesale gas trade is completely transparent; three separate agencies track all transactions and information is made public every two minutes. The wholesale price remains reasonable because of the high level of competition (Figure A3.4). Because gas import is significant, the wholesale price is influenced by what other international buyers, mainly those in Asia, are willing to pay. This has resulted in oil indexation of imported gas prices.

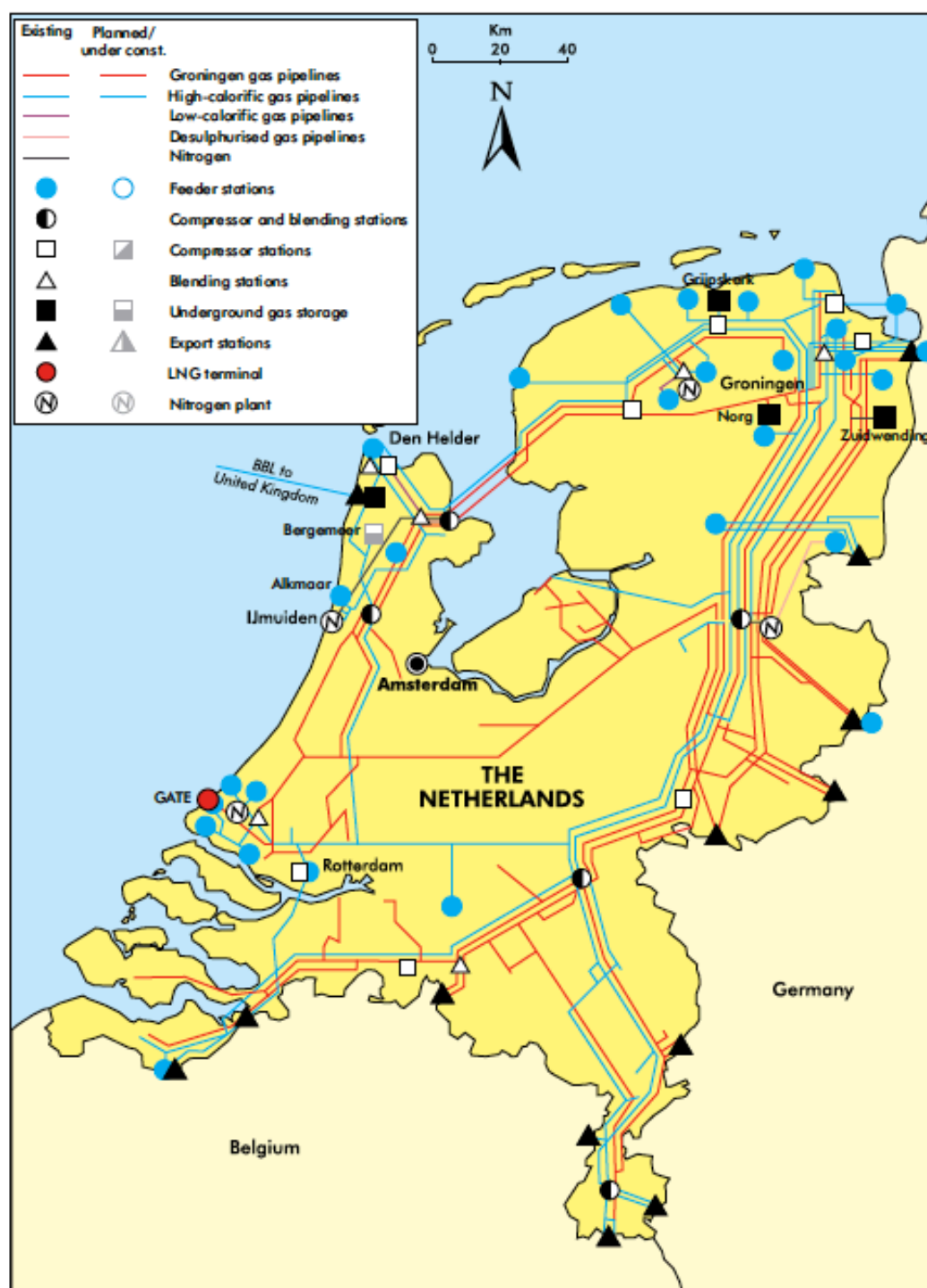
The demand for gas has been falling; the consumption in 2010 was 89.53 BCM. The reduction in gas demand matches the reduction in primary energy consumption that started in 2000. Energy intensity has decreased in the industrial sector and warmer winters have lowered gas use in the residential sector.⁶⁷

Figure A3.4 Monthly Average Global Wholesale Gas Price (NBP Day-Ahead)



Source: Office of Gas and Electricity Markets. The price of £0.60 per therm = £6 per MMBtu = \$9.27

Figure A3.5 Gas network in Netherlands (the)



Source: International Energy Agency

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The gas (and electricity) industry in the United Kingdom has undergone a sea change in the past three decades. The state-owned enterprises were privatized for economic and political considerations. Earlier, coal and oil were the mainstays for energy security; their share in primary energy was 36 per cent and 37 per cent, respectively, in 1980. Then private sector investments started in offshore oil and gas production, which allowed coal use to drop; in 2014 the share of coal dropped to 16 per cent and that of gas became 34 per cent, the same as oil. The share of renewable energy had also grown to 7.4 per cent, from only 0.2 per cent in 1980.

The industry has been unbundled and a large number of participants keep the market competitive. Regulatory oversight has also been changing; in the 1980s the emphasis was on removing the monopoly of the state-owned company and privatizing the assets; the wholesale market started in 1993, initially with 15 20 participants, using standard contracts. The 1996 Network Code established the National Balancing Point for all wholesale trade, which was amended and updated by the 2005 Uniform Network Code. Gas futures contracts were introduced in 1997. By 2014, there were 226 registered participants in the National Balancing Point. The National Balancing Point is considered better than other European gas markets. Its success is attributed to ease of entry, high liquidity, transparency and the large number of participants. The variations in spot prices and future contracts provide signals to suppliers, transporters and producers for planning new investments.

3. The Netherlands' Title Transfer Facility

The consumption of gas in the Netherlands was 38.4 BCM in 2014. It also produced 66.3 BCM of natural gas from onshore and North Sea facilities, which makes it a net exporter. The gas transmission network acts as a major international hub, with 14 interconnection points linking England, Norway, Belgium and Germany. The gas transmission system includes two networks, one for gas with lower heat content (below 10.5 kWh/cm) and the second for gas with higher heat content (10.5 kWh/cm to 12.0 kWh/cm). The production of gas with low heat content is declining and all users are required to shift to high heat content gas by 2020. There are 19 blending stations, 22 compressor stations and four storage facilities. There is also an LNG receiving terminal with a capacity of 12 BCM per year. The total length of the network is about 15,500 km, which can handle about 125 BCM per year (Figure A3.5). Gas production is projected to decrease and the Netherlands is expected to become a net importer of gas sometime after 2020.

The Netherlands started the Title Transfer Facility (TTF) in 2004, which is a virtual market for participants to trade the gas that has already entered the system. Compared to the 100 BCM per year that flows in the network, the volume of gas traded in the over-the-counter markets and exchanges was 13,216 BCM in 2014, which made it the biggest trading hub in Europe.

The gas transmission system is owned by N.V. Nederlandse Gasunie (Gasunie), which is wholly owned by the state. The company has partnership in the interconnector with Great Britain, and also owns the gas network in northern Germany. The domestic gas transmission network was transferred in January 2014 to Gasunie Transport Services B.V. (GTS), a wholly owned subsidiary. GTS is now the independent system operator. The tariff for the transmission service is determined by the Netherlands Authority for Consumers and Markets (ACM), which regulates energy, telecommunications, transport, postal services, and overseas competition and consumer protection in general.

ICE Endex, a partnership of Intercontinental Exchange and Gasunie, manages the spot and derivative gas trade in the TTF. Gas can be traded within the day or a day ahead and futures are available up to five years ahead. The price of gas is tracked by several agencies, including Platts. Table A3.1 is a sample

daily report for 1 May 2015 that lists prices of various future contracts. The large variety of future contracts has helped increase the liquidity in the futures commodity market. A fairly stable price is expected until 2018, with winter prices about 10 per cent higher because of the heating demand.

The Netherlands is currently a gas-exporting country but will need to import gas in the medium term. It is also going to stop supplying gas with low heat content. The government established and strengthened the gas markets to better address these challenges. This gas market is evaluated as the best in Europe, based on having the highest churn ratio in 2014. The transmission system operator is a state-owned enterprise and private sector companies manage the linked financial markets and gas exchanges.

4. Southern African Power Pool

The Southern African Power Pool, formally established in 1995, coordinates the power systems of twelve countries of the Southern African Development Community, namely, Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe. Three member countries (Angola, Malawi and Tanzania) are non-operating, as their power grids are yet to be interconnected with the region. The electric power utilities, transmission companies and independent power producers of the South African Development Community are the 16 members of the Southern African Power Pool.

There are 24 cross-border transmission lines for power trade and bilateral power transfers (Figure A3.6); however, only about 7 per cent of the total electricity produced in the region flows over the interconnections.

The Southern Africa Power Pool began 20 years ago but the level of electricity traded in 2013-2014⁶⁸ is only about 3 per cent of the total power generation. The Day Ahead Market, operating from Harare, Zimbabwe, commenced in 2009, to enable competitive wholesale electricity sale, and in 2013 the Post Day Ahead Market was also introduced to encourage ready use of available capacity. However, nearly all the electricity trade is based on bilateral agreements (8 TWh traded out of a total power generation of 277 TWh) and the competitive wholesale market (Table A3.2) is still at a nascent stage. There is more potential for electricity trade, which is reflected by 1.2 TWh of sell and 1.1 TWh of buy bids received in the competitive market, but transmission constraints have limited the transactions.

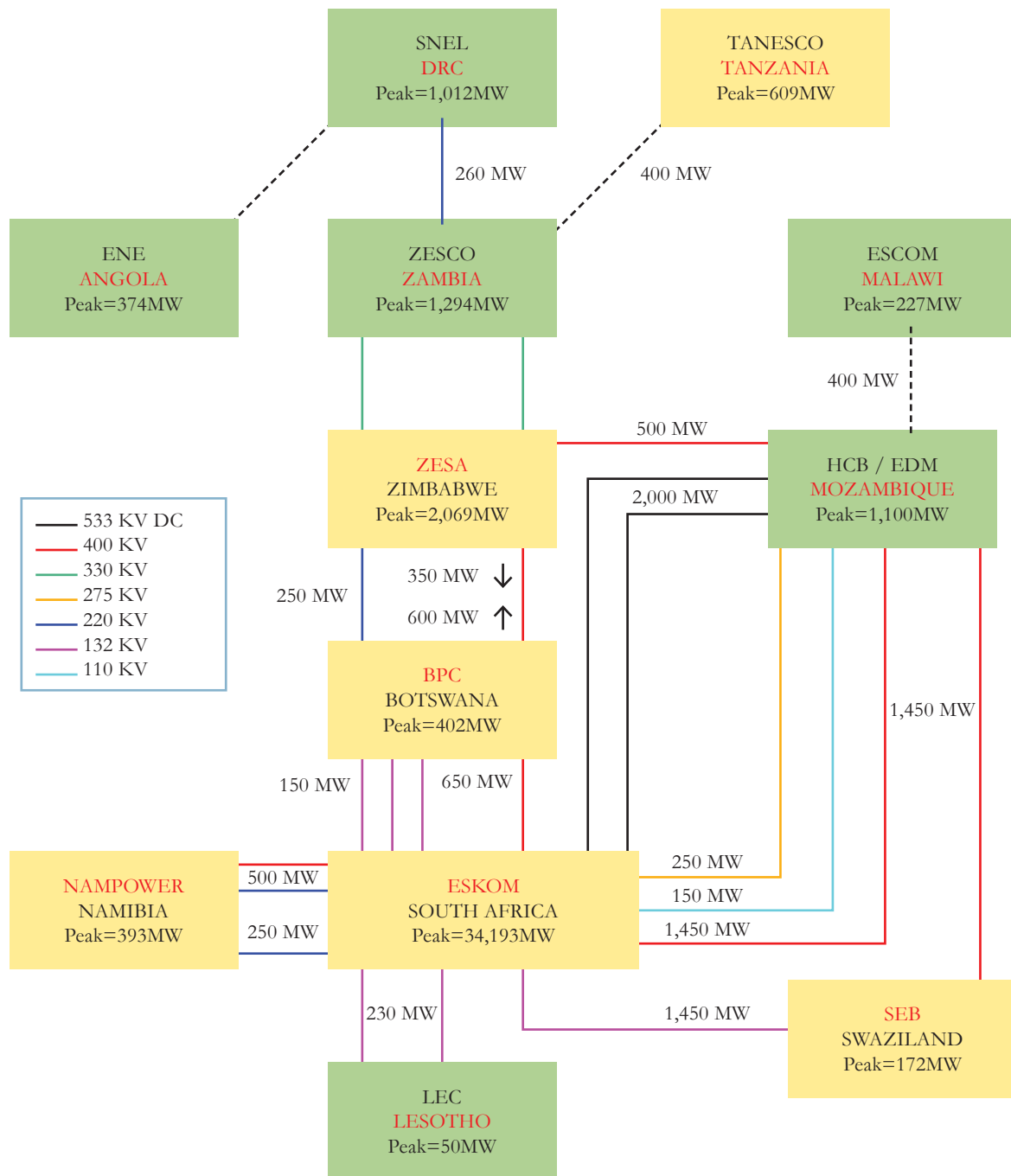
Most of the cross-border trade is from the output of the *Hidroeléctrica de Cabora Bassa* (HCB). The Portuguese government commenced implementation of this 2,075 MW hydropower project in Mozambique and the company was established on 23 June 1975, two days before the country became independent. The construction of the project, together with the 1,400 km high-voltage direct current transmission line to South Africa, was completed in 1979. In November 2007, the Government of Mozambique acquired 85 per cent share of HCB, which increased to 92.5 per cent in April 2012, while

Table A3.1 Platts Dutch TTF Assessment (High-Calorific Gas)

1-May-15	\$/MMBtu	\$/thousand cm
Day Ahead	6.63-6.66	221-222
Day Ahead +1	6.59-6.63	220-221
Weekend	6.59-6.63	220-221
Working Week +1	6.59-6.63	220-221
June	6.56-6.59	219-220
July	6.53-6.56	218-219
Q3 2015	6.55-6.61	218-220
Q4 2015	6.94-7.01	231-234
Q1 2016	7.17-7.24	239-241
Q2 2016	6.78-6.84	226-228
Q3 2016	6.63-6.69	221-223
Q4 2016	7.14-7.20	238-240
Winter 15	7.06-7.12	235-237
Summer 16	6.69-6.76	223-225
Winter 16	7.25-7.32	242-244
Summer 17	6.84-6.91	228-230
Winter 17	7.34-7.40	245-247
Summer 18	6.94-7.10	231-237
Gas Year 2015	6.87-6.94	229-231
Cal 2016	6.94-7.01	231-234
Cal 2017	7.04-7.10	235-237
Cal 2018	7.17-7.24	239-241

Source: Platts, *European Gas Daily*.

Figure A3.6 Interconnection in Southern African Power Pool



Source: Southern Africa Power Pool Internet Website.

the remaining 7.5 per cent of shares remained with *Rede Energética Nacional* (REN) of Portugal. The company initially sold electricity to the Mozambique utility (domestic sale is currently about 25% of the generation) and exported to South Africa. The agreement for export has been revised to allow sale to Zimbabwe and other countries through the market of South African Power Pool. State Grid of China, through its interest in REN, is currently investigating to expand the capacity of the hydropower project by 1,245 MW.

Table A3.2 Southern Africa Power Pool Overview (2013-2014)

Country		Utility	Available Capacity	Maximum Demand	Power Generation	Average Retail Tariff
			MW	MW	GWh	US\$/kWh
1	Angola	ENE	1,805	1,333	5,613	0.060
2	Botswana	BPC	460	580	372	0.070
3	DR Congo	SNEL	1,485	1,342	8,185	0.048
4	Kesotho	LEC	72	138	486	0.059
5	Malawi	ESCOM	351	323	1,809	0.068
6	Mozambique	EDM/HCB	2,279	763	390	0.075
7	Namibia	NamPower	392	635	1,305	0.086
8	South Africa	Eskom	41,074	38,775	237,430	0.087
9	Swaziland	SEC	70	222	288	0.115
10	Tanzania	TANESCO	1,143	898	3,034	0.082
11	Zambia	ZESCO/CEC/LHPC	2,029	2,287	11,381	0.057
12	Zimbabwe	ZESA	1,600	2,267	6,951	0.098
Total			52,760	49,563	277,244	
Reserve Margin				15%		
Shortfall			-4237			
Bilateral Trade					8411	
Energy Traded Competitively					84	

Source: Southern Africa Power Pool Annual Report 2014.

Private sector participation has been minimal in the electricity sector in the region. Only two countries, Mozambique and Zambia, have unbundled generation, transmission and distribution; the others have vertically integrated public sector utilities. Zambia has two independent power companies — one operates 56 MW hydropower generation capacity and the other operates the power transmission system and holds 80 MW diesel-based turbines as reserve. In September 2015, the first 335 MW private sector-owned open cycle peaking power plant commenced operation in South Africa and another 670 MW open cycle peaking power plant is under construction.⁶⁹

Southern Africa Power Pool's generation expansion plan for 2025 includes 14 hydropower plants with a total capacity of 11,700 MW. The World Bank is providing assistance for establishing a Projects Acceleration Team to expedite the preparation of these priority generation and transmission projects that would help strengthen electricity trade. Preparation of bankable projects, together with the functioning power pool, is expected to attract private sector investments.⁷⁰ The largest potential hydropower project in the region is the Grand Inga project on the Congo River, with an estimated capacity of 40,000 MW that can power Southern, Western and Eastern Africa.

During the three-year period since 2011, the average competitive market clearing price has remained fairly stable, between \$55.55/MWh and \$58.93/MWh. Given the low share of power traded through the competitive market, this is not a proper signal for new investments because the region continues to face shortages.

Southern Africa Power Pool is a non-profit organization registered in Zimbabwe. It is under the control of the Directorate of Infrastructure and Services of the Southern Africa Development Community. The Executive Committee is responsible for the overall functioning of the Southern Africa Power

Pool and the heads of all member utilities are its members. A Management Committee is under the Executive Committee, and there are sub-committees for environment, market, operations and planning. A small full-time coordination centre (with nine professional staff members) is located in Zimbabwe. According to the 2014 audited financial results of the Southern Africa Power Pool, the total expense was \$1,912,830, of which staff expense was \$583,498. The income (\$2,246,749) mainly included equal contributions from members, share of the electricity trade, market fees, participation fees, grants (overseas development assistance) and exchange rate gains.

5. Central American Power Market

The six Central American countries have national electricity markets, and have established the Central American Power Market as an additional electricity market. These countries are Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama. A single-circuit 230 kV transmission line system, strung along the western side of these countries, interconnects the power grids of these countries; the towers have the provision to add a second circuit when the demand increases. Sections of Sistema de Interconexión Eléctrica de los Países de América Central (SIEPAC), this 1,793 km transmission system, started operation in December 2010, and the last section commenced operation in October 2014. The capacity of the system is 300 MW. The estimated cost of the second circuit is \$494 million.

In April 2010, the Guatemala power grid was connected with the Mexico grid using a 400 kV, 99 km long, 225 MW capacity transmission line. A 400 MW, 600 km long, high voltage direct current interconnection between Panama and Columbia is also under development, which is planned to be complete in 2018 (Figure A3.7).

The Central America Power Market has been established under the Framework Treaty for the Central American Electricity Market (*Mercado Eléctrico Regional*, MER), ratified in 1998 by the respective parliaments of the member countries. It is based on the principles of competition, gradualism and reciprocity. The MER is the seventh market and not a substitute for the national markets. Three regional agencies have been created for the operation and regulation of the MER, namely: the Regional Operator (*Ente Operador Regional*, EOR, based in El Salvador); Regional Regulator (*Comisión Regional del Interconexión Eléctrica*, CRIE, based in Guatemala); and Regional Transmission Company (*Empresa Propietaria de la Red*, EPR, based in Costa Rica). The last is a public-private company for managing and operating the Central American Electrical Interconnection System (SIEPAC).

The electricity system in the member countries is relatively small and so the SIEPAC has been designed to create a large market for encouraging competition among power producers. Qualified entities anywhere in the region can utilize the facility to carry out electricity trade. The stated objectives of the SIEPAC Project are to: (i) improve security of supply by widening reserve margins; (ii) reduce the problem of electricity rationing in capacity-deficit countries; (iii) achieve improved operating efficiency and reduce the amount of fuel consumption needed for generating electricity; (iv) spur greater competition in domestic markets; (v) lower end-user electricity costs; (vi) attract foreign investment to the region's electricity sector; and (vii) contribute to the economic development of the region.⁷¹

The electricity sector in Costa Rica and Honduras is dominated by vertically integrated utilities but the other four countries have implemented reforms and encourage private sector investments. The existing rules of the regional market do not fully capture the benefits of the interconnection, mainly because of a lack of long-term contracts (at present the longest contract is for a year) and an agreeable and efficient wheeling tariff. The national power grids also require reinforcement. Guatemala benefits from

Table A3.3 Overview of the Electricity Sector in Central America (2014)

	Installed Capacity	Peak Demand	Generation	Generation Share - Renewable	Generation Share - Private	Net Import
	MW	MW	GWh			GWh
Central America	13,667	7,825	46,755	63.9%	65%	
Costa Rica	2,885	1,632	10,118	89.7%	18%	205
El Salvador	1,584	1,035	5,877	59.1%	71%	381
Guatemala	3,134	1,636	9,781	69.6%	74%	-489
Honduras	1,940	1,383	7,789	40.6%	75%	279
Nicaragua	1,312	636	3,999	52.0%	91%	-27
Panama	2,813	1,504	9,191	55.9%	86%	90

Source: United Nations Economic Commission for Latin America (ECLA).

Table A3.4 Electricity Access, Sector Structure and Average Tariff (2014)

	Access to Electricity	Electricity Sector Structure	Average Retail Tariff and Average Spot Market Price
			US\$/MWh
Costa Rica	99.5%	Vertically integrated SOE, cooperatives and IPPs selling to SOE	171.61
El Salvador	93.7%	Unbundled, functioning wholesale market, 13 IPPs active	236.33
Guatemala	78.5%	Unbundled, functioning wholesale market	228.67 – 103.66
Honduras	82.2%	Vertically integrated SOE, IPPs selling to SOE	186.78
Nicaragua	77.9%	Not unbundled but multiple companies; functioning wholesale market	243.45 – 157.38
Panama	90.9%	Unbundled, functioning wholesale market	164.53 – 213.76

Source: United Nations Economic Commission for Latin America (ECLA).

The EU-28 countries have unbundled the electricity sector and have independent transmission system operators responsible for the transmission systems that are natural monopolies. The national transmission system operators are members of the European Network of Transmission System Operators for Electricity (ENTSOE). Electricity is traded in a large number of private sector-owned wholesale electricity markets. A list of power exchanges is in Table A3.6.⁷²

At present, there are seven interconnected electricity markets with power exchanges functioning in EU-28 countries; two of these markets operate within the respective country, others involve more than one country. The seven regional markets are:⁷³

- i. **Central Western Europe:** The participating countries are Austria, Belgium, France, Germany, the Netherlands and Switzerland. There are four power exchanges — EEX Germany, APX Netherlands (the), EPEX France, and BPX Belgium. The monthly total traded volume during the first half of 2015 was about 37 TWh and the average monthly day-ahead baseload price varied between €28/MWh and €41/MWh.

- ii. **British Isles:** The participating countries are United Kingdom and Ireland. There are several electricity products and derivatives that are traded mostly over the counter and on power exchanges — APX Netherlands (the), Intercontinental Exchange (ICE) and N2 Exchange (N2EX, operated by Nordpool). The monthly total traded volume during the first half of 2015 varied between

Table A3.5 Share of Net Import in Electricity Consumption (2014)

Country	Sum of Imports	Sum of Exports	Balance (imp-exp)	Consumption	Net Import/Consumption
	GWh	GWh	GWh	TWh	%
Austria	28,044	18,791	9,253	69.3	13.4%
Bosnia and Herzegovina	3,163	5,998	-2,835	11.6	-24.4%
Belgium	21,698	4,190	17,508	83.7	20.9%
Bulgaria	4,323	13,774	-9,451	31.2	-30.3%
Switzerland	28,116	32,439	-4,323	63.0	-6.9%
Cyprus			0	4.2	0.0%
Czech Republic	11,832	28,138	-16,306	62.0	-26.3%
Germany	38,894	74,588	-35,694	504.9	-7.1%
Denmark	12,785	9,801	2,984	33.3	9.0%
Estonia	3,712	6,530	-2,818	8.2	-34.4%
Spain	12,308	15,481	-3,173	257.8	-1.2%
Finland	21,966	3,858	18,108	83.3	21.7%
France	7,799	73,575	-65,776	465.7	-14.1%
Great Britain	23,169	3,704	19,465	330.6	5.9%
Greece	9,565	684	8,881	49.3	18.0%
Croatia	10,905	6,228	4,677	16.4	28.5%
Hungary	19,083	5,695	13,388	39.5	33.9%
Ireland	2,813	672	2,141	26.2	8.2%
Iceland			0	17.7	0.0%
Italy	46,756	3,008	43,748	308.4	14.2%
Lithuania	8,520	898	7,622	10.7	71.2%
Luxembourg	6,971	2,052	4,919	6.3	78.1%
Latvia	5,338	3,023	2,315	7.4	31.3%
Montenegro	4,027	3,640	387	4.4	8.8%
FYROM (Macedonia)	5,598	2,637	2,961	7.9	37.5%
Northern Ireland	1,613	314	1,299	9.3	14.0%
Netherlands (the)	32,853	17,899	14,954	110.9	13.5%
Norway	6,148	20,879	-14,731	125.2	-11.8%
Poland	13,509	11,342	2,167	146.9	1.5%
Portugal	7,247	6,343	904	48.8	1.9%
Romania	1,363	8,493	-7,130	53.3	-13.4%
Serbia	7,330	5,049	2,281	38.2	6.0%
Sweden	16,148	32,513	-16,365	135.6	-12.1%
Slovenia	7,249	9,962	-2,713	13.2	-20.6%
Slovak Republic	12,964	11,861	1,103	26.1	4.2%

Source: European Network of Transmission System Operators for Electricity.

about 60 TWh and 115 TWh. The monthly average day-ahead price in United Kingdom varied between €57/MWh and €61/MWh, the highest in Europe, mainly because of the increase in climate change levy from April 2015; the monthly average wholesale price in Ireland varied between €48/MWh and €54/MWh.

- iii. **Northern Europe:** The participating countries are Denmark, Estonia, Finland, Latvia, Lithuania, Norway and Sweden. Electricity is traded on the Nordpool. The monthly traded volume during the first half of 2015 varied between about 26 TWh and 36 TWh, and the monthly average day-ahead baseload price varied between €13/MWh and €31/MWh, the lowest in Europe, mainly because of high hydropower generation.
- iv. **Apennine Peninsula (Italy):** The average monthly traded volume in the first half of 2015 was about 16 TWh and the average monthly day-ahead baseload price was about €50/MWh.
- v. **Iberian Peninsula:** Portugal and Spain are the member countries. Together, the average monthly traded volume of electricity in the two countries added to about 18 TWh and the monthly average day-ahead baseload price varied from €44/MWh in Spain and €43/MWh in Portugal to €55/MWh in both countries.

Table A3.6 Power Exchanges in Europe

Power Exchange	Countries
APCS - Power Clearing and Settlement	Austria
APX - Power Spot Exchange Merged: EPEX – European Power Exchange	The Netherlands, United Kingdom
Belpex (Part of APX-ENDEX)	Belgium
Borzen	Slovenia
CROPEX - Croatian Power Exchange	Croatia
EEX - European Energy Exchange	Germany, Austria, France, Switzerland
ELEXON	United Kingdom
EXAA - Energy Exchange Austria	Austria
GME - Gestore dei Mercati Energetici	Italy
HUPX - Hungarian Power Exchange	Hungary
ICE ENDEX - Intercontinental Exchange	The Netherlands
LAGIE - Hellenic Electricity Market Operator	Greece
Nasdaq OMX	Norway
Nord Pool Spot	Norway, Sweden, Finland, Denmark, Estonia, Lithuania
Nord Pool – N2EX	United Kingdom
OKTE	Slovakia
OMIE	Spain
OMIP	Portugal
OPCOM - Operatorul Pieteii de Energie Electrica si Gazelor Naturale	Romania
OTE	Czech Republic
PXE - Power Exchange Central Europe	Czech Republic
SEMO - Single Electricity Market Operator	Ireland
TGE - Polish Power Exchange	Poland

Source: United Nations Economic Commission for Latin America (ECLA).

- vi. **Central Eastern Europe:** The member countries are Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia. The monthly total electricity traded in the different country power exchanges was about 6.7 TWh during the first half of 2015. The average monthly day-ahead baseload price varied between €30/MWh and €48/MWh.
- vii. **Southeastern Europe (Greece):** The average monthly traded volume in Greece was about 4.5 TWh during the first half of 2015. The average monthly day-ahead baseload price varied between €48/MWh and €62/MWh.

Countries in southeast Europe had a unified electricity system that has disintegrated but they are unable to function independently. They established the Energy Community in 2006 and by 2013 it had nine members, the European Union and eight contracting parties — Albania, Bosnia and Herzegovina, Kosovo, former Yugoslav Republic of Macedonia, Moldova, Montenegro, Serbia and Ukraine. This region is being informally referred to as Europe's eighth electricity market. These countries have agreed to fast-track the transformation of the electricity sector so they become compliant to the European energy laws.

The European electricity markets and cross-border trade are commonly considered well advanced. However, further market integration would increase competition and lead to greater efficiency through better use of generation resources. The EU has an ambitious climate policy and has the goal to provide secure, sustainable, competitive and affordable energy to its consumers, both households and businesses. To achieve this, it is seeking a fundamental transformation of the energy system.

In February 2015, the European Commission announced its plan to create the European Energy Union. This strategy has five interrelated dimensions for bringing greater energy security, sustainability and competitiveness: (i) energy security, solidarity and trust; (ii) fully integrated European energy market (electricity and gas); (iii) energy efficiency contributing to moderation of demand; (iv) decarbonizing the economy; and (v) research, innovation and competitiveness. The vision presented in the communication is quoted in Box A3.⁷⁴

7. Pennsylvania-New Jersey-Maryland Interconnection (PJM)

A brief description of the Pennsylvania-New Jersey-Maryland Interconnection (PJM) in the United States has been included in the Appendix although it

WHY WE NEED AN ENERGY UNION

Box A3. Goal and Vision of the European Energy Union

The goal of a resilient Energy Union with an ambitious climate policy at its core is to give EU consumers — households and businesses — secure, sustainable, competitive and affordable energy. Achieving this goal will require a fundamental transformation of Europe's energy system.

Our vision is of an Energy Union where Member States see that they depend on each other to deliver secure energy to their citizens, based on true solidarity and trust, and of an Energy Union that speaks with one voice in global affairs;

Our vision is of an integrated continent-wide energy system where energy flows freely across borders, based on competition and the best possible use of resources, and with effective regulation of energy markets at EU level where necessary;

Our vision is of the Energy Union as a sustainable, low-carbon and climate-friendly economy that is designed to last;

Our vision is of strong, innovative and competitive European companies that develop the industrial products and technology needed to deliver energy efficiency and low carbon technologies inside and outside Europe;

Our vision is of a European labour force with the skills to build and manage the energy system of tomorrow;

Our vision is of investor confidence through price signals that reflect long term needs and policy objectives;

Most importantly, our vision is of an Energy Union with citizens at its core, where citizens take ownership of the energy transition, benefit from new technologies to reduce their bills, participate actively in the market, and where vulnerable consumers are protected.

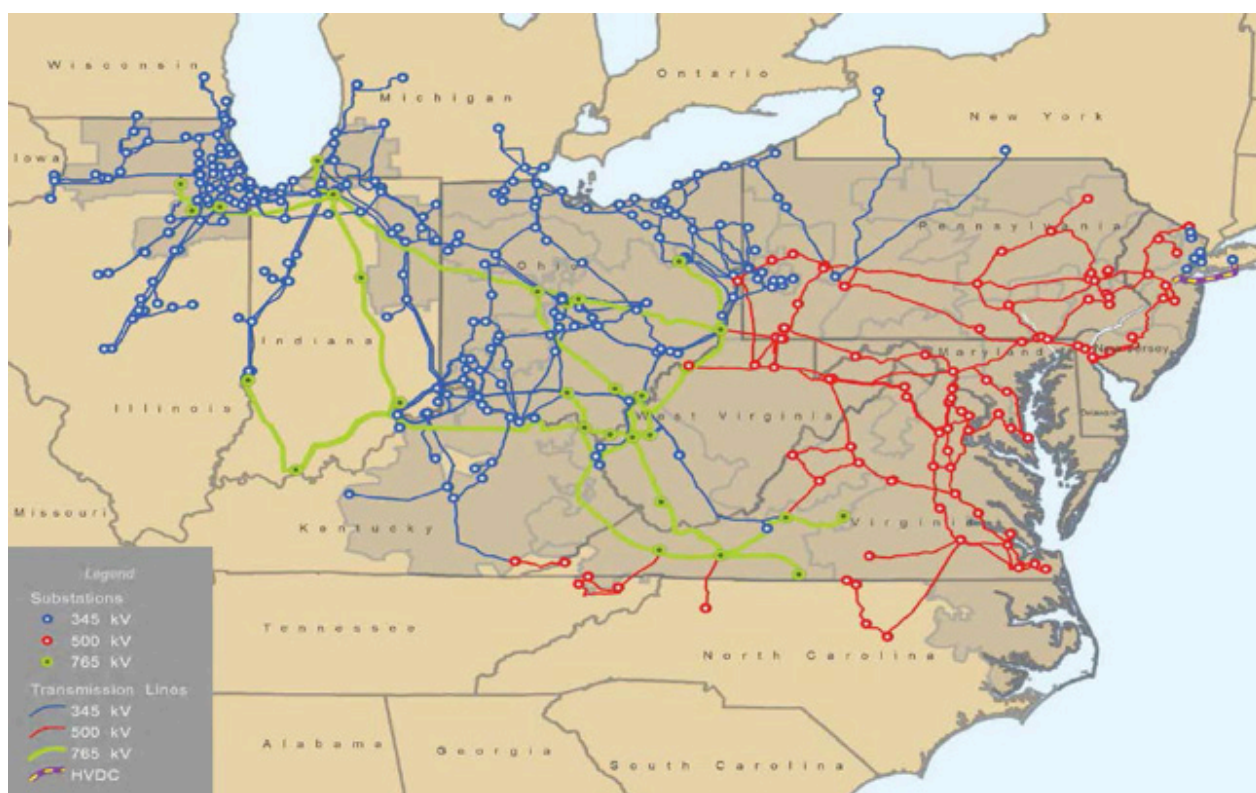
does not deal with cross-border electricity trade. The market model offers useful lessons as it enables efficient delivery of electricity services across many utilities. Under the federal government system, every state administration considers security, reliability, sustainability and affordability of electricity supply to be of utmost importance. PJM operates a competitive electricity market that satisfies the needs of all participating states by sharing resources, which is similar to the regional electricity connectivity sought in Asia and the Pacific region. However, the Federal Energy Regulatory Commission (FERC) maintains oversight of the market, which is very different from a market involving different countries that has no obvious regulatory authority to review market rules and resolve disputes.

The United States has a long history of private sector utilities that had monopolies over generation, supply and distribution and were subject to state-level regulation. With the introduction of competitive electricity markets in 1990s, the electricity sector was unbundled in most regions and various market designs were introduced. The PJM started operating a power pool for three states (Pennsylvania, New Jersey and Maryland) in 1956; it became the independent system operator in 1996 and started a wholesale electricity market in 1997 with bid-based and locational market pricing. Now PJM covers Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and District of Columbia. Figure A3.8 shows the participating states and backbone transmission lines of PJM. In addition to physical electricity trade, there are markets for electricity derivatives, ICE being the largest. PJM dominates the ICE derivative market with 73 per cent of the total financial trades in 2014.

The United States has ten electricity regions; three of these continue to function under the traditional structure with vertically integrated utilities. The remaining regions, which constitute two thirds of the electricity use in the United States, have regional transmission operators or independent system operators that manage the transmission system and operate the wholesale electricity market. PJM has over 940 market participants, the total installed capacity is 184 GW, peak demand is 165 GW, annual energy sales is 838 TWh; it is a little less than one fifth of the EU-28 electricity system in terms of capacity and one fourth in terms of energy sales. PJM is the first-ranked region in terms of installed capacity and electricity sales. PJM operates competitive markets for several electricity products:⁷⁵

- i. Energy market comprises real-time (five minutes) and day-ahead markets;
- ii. Capacity market is based on reliability pricing model that ensures availability of long-term resources for meeting future demand;
- iii. Under demand response, retail customers receive payments for curtailing their electricity use when requested by PJM during periods of high prices or when system reliability is threatened;
- iv. Financial transmission rights are financial contracts for hedging supply risks related to transmission constraints;
- v. Ancillary markets include the synchronized reserve market, the non-synchronized reserve market, the day-ahead scheduling reserve market and the regulation market.

Figure A3.8 PJM Electricity Region and Backbone Transmission System



Source: www.ferc.gov.

Disclaimer: The boundaries and names shown and designations used on this map do not imply official endorsement or acceptance by the United Nations.

The 2014 total average wholesale electricity price in PJM was \$71.62/MWh, which was 33 per cent higher than in 2013. The main components of total wholesale electricity price were load-weighted energy (74%), capacity (13%), transmission service (8%), and energy uplift or reserve (2%); the remaining 3 per cent was evaluated over 16 items.

According to PJM's estimate, the integration of the electricity networks in the 13 states and District of Columbia results in an annual saving of \$2.8 billion to \$3.1 billion in the areas of generation investment, energy production, grid service, reliability and integration of more efficient resources.

FERC requires an independent entity to review the operation of all independent system operators. Accordingly, Monitoring Analytics LLC carries out quarterly and annual reviews of PJM's operation. These reports, containing thorough analysis of all aspects of the market, are disclosed on the firm's and FERC websites.

- 1 IEA 2014. Comparable data from IEA is available for only 34 regional countries.
- 2 Strait of Hormuz connects the Persian Gulf with the Gulf of Oman and the Arabian Sea.
- 3 From dominant fossil fuel-based energy systems to increasing share of renewable energy, from vertically integrated to liberalized market systems, from centralized energy sources to distributed energy systems or integrating climate risks in energy systems. There is also a large portfolio of new technologies that have now become viable and can be introduced beneficially.
- 4 Remarks to High-level Event on Sustainable Energy for All, 24 September 2012, at UN Headquarters, New York.
- 5 Data sourced from IEA 2014. Comparable data from IEA is available for only 34 regional countries.
- 6 BP 2014. BP Statistical Review of World Energy 2014. <http://www.bp.com/statisticalreview>
- 7 Strait of Hormuz connects the Persian Gulf with the Gulf of Oman and the Arabian Sea.
- 8 U.S. Energy Information Administration (EIA). 2014. World Oil Transit Chokepoints. Last updated 10 November 2014. Available at <http://www.eia.gov/countries/regions-topics.cfm?fips=wotc>
- 9 The Strait of Malacca is located between Indonesia, Malaysia and Singapore, and links the Indian Ocean to the South China Sea and Pacific Ocean.
- 10 As per M. Pezzini, 2012, OECD study, the size of the “global middle class” will increase from 1.8 billion in 2009 to 3.2 billion by 2020 and 4.9 billion by 2030. The bulk of this growth will come from Asia. By 2030 Asia will represent 66% of the global middle-class population and 59% of middle-class consumption, compared to 28% and 23%, respectively, in 2009. This will have a major impact not only on the energy consumption, but also other goods that have high energy and carbon contents.
- 11 Jaber and Glocker. 2015. Shifting towards low carbon mobility systems Discussion Paper No. 2015 17, International Transport Forum.
- 12 Finance & Development, The Low-Carbon Road December 2015, Vol. 52, No. 4
- 13 It is easier to trade coal and oil where transport by sea is readily available and there are established global markets.
- 14 It is at least possible in the context of a nation to distribute costs and gains fairly among different groups, but when many countries are involved, there are no easy transfer mechanisms.
- 15 ADB. Strategy and Work Plan (2016–2020) for Regional Cooperation in the Energy Sector of CAREC Countries. September 2015, Manila.
- 16 www.eaeunion.org
- 17 Average annual global horizontal irradiance (GHI) at 3km spatial resolution in Watts per square metre (W/m²) for solar and average annual wind speed at 80m across the Region in metres per second (m/s).
- 18 OECD/IEA. 2014. World Energy Outlook 2014. International Energy Agency. Paris, France.
- 19 In some sense, solutions were relatively simple, too: collective stockpiling was seen as a major solution for oil-importing countries.
- 20 Colglazier Jr., E.W. & Deese, D.A. 1983. Energy and security in the 1980s. Annual Review of Energy Volume 8(1): 415–449, November 1983
- 21 Available at <http://www.globalenergyassessment.org>
- 22 Sovacool, B. 2011. Energy Policy 39 (2011): 7472–7479
- 23 Winzer reviewed as many as 38 different definitions of energy security. Winzer C. Conceptualizing energy security. Energy Policy 2012: 46–36.
- 24 Energy security contributes significantly to three important dimensions of human security: economic security, food security and health security. For many decades, the links between energy and human well-being were not adequately recognized and this has now been rectified. The Sustainable Development Goal number 7 now places secure energy supplies at the heart of overall development.
- 25 Berkeley Earth, a non-profit foundation began collecting world’s air pollution data in April 2014. The above conclusion is based on data from April 2014 to August 2015. Available at <http://www.berkeleyearth.org>.
- 26 World Politics, Vol. 32, No. 3 (April 1980): 357–405
- 27 Sakakibara, E. & Yamakawa, S. 2003. Regional Integration in East Asia: Challenges and Opportunities, Part 1: History and Institutions. Policy Research Working Paper 3078, World Bank, Washington, D.C
- 28 Kaijser, A., van der Vleuten, E. & Högselius, P. 2015. Europe’s Infrastructure Transition Palgrave Macmillan, UK p. 2
- 29 Regions with abundant wind and solar resources are often located far from demand centres. The Atacama Desert in South America, for example, has some of the highest solar potential in the world, with little local demand for electricity. In China, wind resources are generally most abundant in the west, far from population centres in the east. In Inner Mongolia, where wind power generation is high, the Inner Mongolia Power Company exports power generated from wind to Mongolia, where demand is higher. In the United States, wind resources are most abundant in the Midwest and solar potential is highest in the Southwest, while demand for electricity is higher on the East and West Coasts. In essence, power generation and demand centres are often quite dispersed geographically and increasingly vast and interconnected power grids can efficiently link renewable power generation to demand.
- 30 HHI indicates level of concentration, normally used to assess competition and market power in any sector. The Index was used to measure of concentration or diversity of fuel sources for power generation in all countries. The index is calculated as the sum of the squared shares of six types of fuels, namely coal, oil, nuclear, hydroelectric, natural gas and renewables other than hydropower from the data given in the World Development Indicators. HHI Index value of 1 will mean single source of fuel dependency. The lower the value, the more diverse is the power generation in a country.
- 31 Minister for Economic Affairs, the Netherlands, speech at the 25th meeting of the Energy Charter Conference in November 2014.
- 32 ADB. 2014 Annual Report. 2015. Manila
- 33 Platts. Special Report: Oil, FOB Singapore beyond Singapore-Towards FOB Straits. 2014. www.Oil.Platts.Com
- 34 Vlado Vivoda. Natural gas in Asia: Trade, markets and regional institutions. Energy Policy. 2014. Elsevier

- 35 World Economic Forum. Managing Transitional Infrastructure Programmes in Africa — Challenges and Best Practices. 2014. Geneva.
- 36 Secretary-General's remarks at Summit for the Adoption of the Post-2015 Development Agenda 25 September 2015, New York
- 37 From dominant fossil fuel-based energy systems to increasing share of renewable energy, from vertically integrated to liberalized market systems, from centralized energy sources to distributed energy systems or integrating climate risks in energy systems. There is also a large portfolio of new technologies that have now become viable and can be introduced beneficially.
- 38 Professor of International Affairs, Princeton University
- 39 IEA. World Energy Investment Outlook. Paris. 2014.
- 40 ADB Institute and ADB. Infrastructure for Asian Connectivity. Manila. 2012
- 41 ADB, InterAmerican Development Bank, The World Bank. Public-Private Partnerships Reference Guide Version 2.0. 2014. Washington DC. A similar reference to performance-linked revenue is included in the PPP definition given in the November 2015 Government of India report titled Report of the Committee on Revisiting and Revitalising the Public Private Partnership Model for Infrastructure
- 42 The paragraph numbers are taken from the Ministerial Declaration.
- 43 Emissions from fossil fuel-based power projects include those with impact on the local environment such as sulfur oxides, nitrogen oxides, particulate matter and effluents, and those with global impact through climate change because of carbon dioxide emission.
- 44 ASEAN, CAREC, GMS, SAARC and others.
- 45 Exchange rate of \$1.1258=Euro1 on 7 October 2015.
- 46 <https://www.iea.org/aboutus/faqs/organisationandstructure/>
- 47 Information regarding the cross-border power transmission lines and gas pipelines is not readily available in the public domain. These have been developed for bilateral trade, mostly by the governments. Information regarding existing interconnections and those under implementation is included in this appendix but it is not exhaustive
- 48 www.ferc.gov. Energy Primer, a Handbook of Energy Market Basics. Washington DC. 2015. This publication is the source of other general information in this Appendix.
- 49 Methane, the main component of natural gas, has a global warming potential 21 times that of carbon dioxide.
- 50 International Gas Union. World LNG Report – 2014 Edition. Norway. Downloaded from <http://www.igu.org/>. Further, 1MT of LNG is equivalent to 1.3 billion cubic metres (BCM) of gas.
- 51 Vlado Vivoda. Natural gas in Asia: Trade, markets and regional institutions. Elsevier Ltd. 2014
- 52 Downloaded from <http://www.cnpc.com.cn/en>
- 53 Downloaded from <https://www.ema.gov.sg>
- 54 Downloaded from <http://www.aseanenergy.org>
- 55 Downloaded from <http://www.apec.org>
- 56 ADB. Greater Mekong Subregion Power Trade and Interconnection, 2 Decades of Cooperation. 2012. Manila.
- 57 Brunei Darassalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA) Implementation Blueprint (2012 – 2016). 2012. Downloaded from <http://bimp-eaga.org>
- 58 ADB. Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT) Implementation Blueprint (2012–2016). 2012. Manila.
- 59 CAREC. Strategy for Regional Cooperation in the Energy Sector of CAREC countries. Baku. 2008. Downloaded from www.carecprogram.org.
- 60 Downloaded from <http://www.saarc-sec.org>.
- 61 Downloaded from <http://sasec.asia>
- 62 Framework for Pacific Regionalism. Adopted in 2014. Downloaded from <http://www.forumsec.org.fj>
- 63 Ministry of Foreign Affairs. Northeast Asia Peace and Cooperation Initiative, Moving Beyond the Asian Paradox Towards Peace and Cooperation in Northeast Asia. Seoul. 2015.
- 64 Downloaded from <https://www.ferc.gov>; State of the Markets 2014, staff report.
- 65 The extensive gas pipelines also act as gas storage, which is known as linepack. The pressure in the gas pipelines is normally far higher than what large consumers require so it can be dropped for increasing the withdrawal for short durations without increasing the supply.
- 66 National Grid. National Grid Annual Report 2014/2015. London. 2015.
- 67 Department of Energy and Climate Change. Energy Consumption in the UK 2015. London. 2015. The gas consumption data is downloaded from the website of the Office of Gas and Electricity Markets (<https://www.ofgem.gov.uk>) and National Grid (www.nationalgrid.com/uk).
- 68 The accounting year is from 1 April 2013 to 31 March 2014.
- 69 Downloaded from Power Engineering International website on 2 December 2015.
- 70 International Development Association. Southern Africa Power Pool — Program for Accelerating Transformational Energy Projects. 2014. Washington
- 71 The World Bank. Regional Power Integration: Structural and Regulatory Challenges. Washington. January 2011.
- 72 The list may not be exhaustive or updated; these are private sector-owned and the companies are often restructured or merged.
- 73 European Commission, Directorate-General for Energy. Quarterly Report on European Electricity Markets Quarter 2, 2015. Brussels. 2015.
- 74 European Commission. A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy. Brussels. 2015.
- 75 www.pjm.com

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